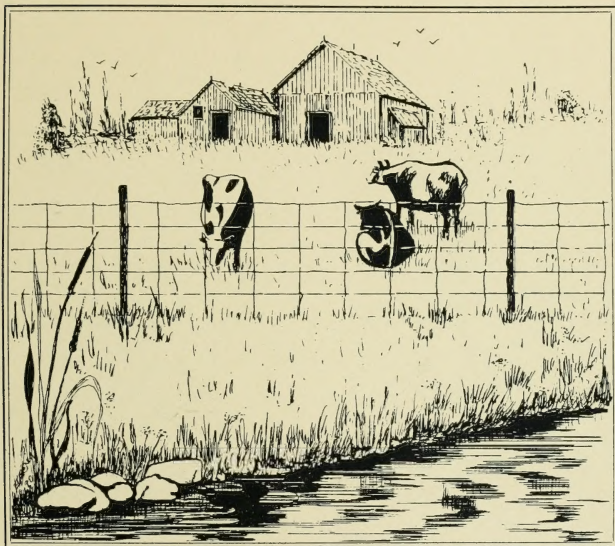


2305

CLEAN UP RURAL BEACHES (CURB) PLAN

FOR THE INDIAN RIVER WATERSHED



PRODUCED BY
THE OTONABEE REGION
CONSERVATION AUTHORITY

FOR THE ONTARIO MINISTRY OF THE ENVIRONMENT

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DISCLAIMER

This report has been reviewed by the local Technical Steering Committee and approved for publication. Approval does not necessarily signify that the contents reflect the position and/or policies of individual agencies.

FOREWORD

This report is one of a series produced under the Provincial Rural Beaches Program. The objective of the Program is to identify the relative impact of pollution sources, and develop a course of action leading to the restoration and long term maintenance of acceptable water quality at provincial rural beaches.

Significant enrichment and bacterial contamination in southern Ontario rivers and lakes originates from rural sources. The discharge of waste material to streams can result in elevated bacterial concentrations, nuisance algae blooms, fish kills, and present a potential health hazard to humans and livestock using the water. Watershed studies have found that a multitude of pollution sources and pathways may affect beaches in Ontario. These include:

- 1) Urban sanitary and stormwater runoff,
- 2) Direct livestock manure access to watercourses,
- 3) Inadequate manure management practices,
- 4) Direct discharge of milkhouse wastes,
- 5) Contaminated field tile systems, and
- 6) Faulty septic systems

The impact upon beaches of any of these sources, either singly or in combination, can range from a few days of elevated concentrations to complete seasonal closures.

Numerous beach closings in 1983 and 1984, drew public and government attention to the severity of this water quality problem. In 1985, the Ontario Ministry of the Environment's (MOE) Water Resources Branch formulated the Provincial Rural Beaches Strategy Program. Directed by the Provincial Rural Beaches Planning and Advisory Committee, it includes representatives from MOE, Ministry of Agriculture and Food (OMAF), and Ministry of Natural Resources (MNR).

With financial and technical assistance from the MOE, local Conservation Authorities carry out studies under the direction of a local technical steering committee. Chaired by an MOE regional staff, the committees typically include representation from OMAF, MNR, the Medical Officer of Health, Conservation Authority, the local Federation of Agriculture, and a local farmer. The chairs of the local committees assure communication between all the projects by participating on the Provincial Committee.

The primary objective of each local study is to identify the relative impact of pollution sources, their pathways to beaches, and to develop a Clean Up Rural Beaches (CURB) plan specific to the watershed upstream of each beach. The CURB plan develops remedial strategy options and respective cost estimates for each beach through:

- 1) Field inspections,
- 2) Farmer consultations,
- 3) Water quality monitoring, and
- 4) Basic mathematical modelling techniques.

Recommended actions will include both measures for specific beaches and broader scale Provincial measures based on cumulative results of component studies.

The following related research projects were also MOE funded and undertaken by various Conservation Authorities to improve our understanding of bacterial and nutrient dynamics:

- 1) Insitu bacterial survival studies determine longevity: in watercourses, offshore of beaches, in sediments, and in milkhouse washwater tiles.
- 2) Biotracer studies determine the speed and nature of travel for bacteria introduced into a watercourse.
- 3) A liquid manure spreading study examines bacterial movement through the soil column and exiting field tile drains.
- 4) A target sub-basin study evaluates the effectiveness of a watershed with comprehensive remedial measures.

Numerous demonstration farms have been established with the cooperation of local farmers to display innovative management practices. Research continues on their effectiveness at improving water quality.

Comments and/or questions on this report are welcome. Please send written comments to:

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INDIAN RIVER BEACHES STUDY

1986, 1987

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OTONABEE REGION CONSERVATION AUTHORITY

JUNE, 1988

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We would like to express our appreciation to the members of the Steering Committee for the Indian River Beaches Study and staff members from the Otonabee Region Conservation Authority for their assistance in the preparation of this report.

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INDIAN RIVER WATERSHED 1991 CURB UPDATE

In 1987, when the study period ended in the Indian River watershed, a remedial action (CURB) plan was included in the report. At the time of the report it had not yet been established what a CURB Plan would consist of; therefore the CURB Plan was based upon what work could be done to produce the largest positive impact on the watercourse in the most cost effective manner. During the study period beaches were prioritized for remedial work based on benefit and use, and those properties which had the greatest single source impact on the beaches were identified using time of travel and bacterial die off data. It was determined that our primary targets were farms rated as having a high pollution potential, located along the main watercourse in close proximity to a beach.

In the four years since that time a great deal has changed, insofar as implementing guidelines for CURB plans, the use of modelling in order to calculate the percentages of bacterial contributions and projected reductions from various sources, and the type of works which adequately address each situation. As an example, when fencing to restrict cattle access to a watercourse, allowing a limited access point was considered a cost efficient alternative in 1987. It has since been determined that limited access points create a point source of pollution, therefore cattle access must be completely restricted and an alternate source of water supplied. It was also pointed out in the 1987 CURB Plan that although the properties listed in the CURB would be the most pressing problems to address, there are many other projects which need to be implemented to improve water quality. As a result, as we move into the implementation phase, needs have been reassessed based upon large scale clean up of the Indian River watershed.

During the study period, landowner interviews identified a total of 60 farms as having high pollution potential, 25 as medium and 48 as low. Of these, 70 properties have unrestricted livestock access to a watercourse, 25 have manure storages less than 50 metres from a watercourse with no liquid runoff containment, and potentially 15 landowners were inadequately handling their milk house waste.

As the CURB Plan was concentrating on agricultural sources, septic systems were not included in the original cost benefit analysis. Our cottage and rural residential survey identified 63 potentially inadequate sanitary waste disposal systems. Inadequate farm septic systems are not included in this number making this particular estimate very conservative.

The following is an updated estimate of CURB costs in the Indian River watershed:

<u>PROBLEM</u>	<u># OF SITES</u>	<u>TOTAL CURB COST</u>
Livestock Access (Included in CURB)	15	\$ 101,250.
Additional Livestock Access	55	\$ 371,250.
Manure Storage/ Barnyard Runoff	25	\$ 575,000.
Septic System Inadequate	63	\$ 252,500.
Other:		
Mid-Level Crossover	5	\$ 10,000.
	-----	-----
Total	163	\$ 1,310,000.
	=====	=====

This figure more realistically reflects the need throughout the Indian River watershed for implementation of the CURB Plan.

May 16, 1991

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SUMMARY

A two-year water quality study of the Indian River was undertaken by the Otonabee Region Conservation Authority during the years 1986 and 1987 to identify the problems responsible for beach closures along the river in recent years. The primary objectives of the study, funded by the Ontario Ministry of the Environment, were to determine land-use practices that may be contributing contaminated drainage to the Indian River in the vicinity of public beaches, and to identify viable remedial measures to reduce or eliminate these impacts. The two major components of the study included a water quality field sampling program and a landowner contact program.

Results from the study indicated that beach closures along the Indian River are primarily related to agricultural land-use practices, especially unrestricted cattle access to waterways. Beach closures at the Warsaw Caves Conservation Area, Douro Municipal Park and the Hope Mill Conservation Area were also shown to be correlated with high precipitation levels, whereas closures at the Lang Mill Conservation Area beach appeared to be affected primarily by immediate sources of bacterial contamination and were not related to rainfall events.

Two sections of the river had seasonal bacterial levels above the M.O.E. Water Quality Objective of 100 FC/100 ml. These areas included a 6.5 km stretch of the river from Guerin to approximately 3 km south of Highway 7, and a 4.5 km length of river from Lang Mill beach to the Keene bridge. High bacterial levels in the upstream section are primarily the result of farming practices along both the main river and tributaries entering in this region. Bacterial problems in the downstream section of the river appear to be the result of farming practices and urban related causes.

The most severe water quality problem encountered in this study was in the Keene Village tributary, where bacterial and chemical levels both years were very high. An investigation by the Peterborough County-City Health Unit led to a clean up/or replacement of septic systems at a local business and private residences within the village.

Rain event sampling during 1987 showed that fecal coliform levels in the river tended to peak approximately 24 hours after rainfall began. Bacterial sediment sampling at the four beach areas showed that bacterial levels were higher after disturbance of sediments at all beaches except Warsaw Caves. This was related to the small amount of sediment overlying the limestone bedrock at Warsaw.

Sampling for the bacterial indicator Pseudomonas aeruginosa showed that levels of this bacterium were usually less than 10/100 ml except in the Keene Village tributary where counts ranged from less than 10/100 ml to 650/100 ml. Analysis for fecal coliforms and Escherichia coli bacteria showed that E. coli ranged from 7% to 100% of the fecal coliforms with a mean of 70% for the watershed. Levels of nutrients and suspended solids in the main channel of the Indian River appear to be quite acceptable.

Results from the landowner contact program showed that 45% of landowners with large properties ranked as high potential polluters to the waterway. Land-use practices which were responsible for these high rankings included unrestricted cattle access to the main river or tributary, runoff from feedlots and manure storage areas, manure handling practices and disposal of milkhouse wastes. Results showed that 24% of those households interviewed had potentially inadequate waste disposal systems. It was evident from the interview process that information and education programs are required to inform landowners about the environmental impacts of pollution to waterways.

1.0 INTRODUCTION

In recent years there has been an increased awareness in the Peterborough area of beach pollution problems, highlighted by beach closures from 1984-1987. The Indian River Beaches Study was a two-year program initiated in 1986 to investigate the reasons for beach closures along the Indian River, which is situated approximately 11 km east of the City of Peterborough. There are four public beach areas on the Indian River, located at the Warsaw Caves Conservation Area, Douro Municipal Park, Hope Mill Conservation Area, and Lang Mill Conservation Area (Fig. 1). Additionally, there are several non-designated swimming areas along the watercourse.

Funding for this study was provided to the Otonabee Region Conservation Authority by the Ontario Ministry of the Environment. The Technical Steering Committee overseeing the study is made up of representatives from the Ontario Ministry of the Environment, the Ontario Ministry of Agriculture and Food, the Peterborough County-City Health Unit, the Regional Public Health Laboratory in Peterborough, and the Otonabee Region Conservation Authority.

The primary objectives of the Indian River Beaches Study

Figure 1. Indian River Watershed With
1987 Water Quality Sampling
Stations.



have been to determine land use practices that may be contributing contaminated drainage to the Indian River in the vicinity of public beaches and to identify viable remedial measures to reduce or eliminate these impacts. The two components of the study include:

1. a water quality field sampling program;
2. a landowner contact program.

This report summarizes the work undertaken on the study during 1987 with some reference and comparison to the 1986 study season. It includes the data collected during this time period together with analyses and conclusions leading to a remedial action plan for the Indian River watershed.

Field sampling during 1986 took place from May 27 - September 30 at 32 stations. In 1987 the sampling program ran from March 23 - October 5 with data collected at 36 stations along the river and its tributaries.

High priority was also given to a landowner contact program during both years of study. In 1986, 133 landowners with 10 acres or more of land adjacent to a watercourse were contacted to obtain information regarding land use practices on their property. In 1987, 259 owners of properties with

less than 10 acres adjacent to a watercourse were interviewed. These interviews concentrated on water supply and sewage disposal systems and were set up with the assistance of the Peterborough County-City Health Unit.

2.0 THE INDIAN RIVER WATERSHED

2.1 Geomorphology and Soils

The Indian River Watershed is divided into two physiographic regions, the Dummer Recessional Moraine and the Peterborough Drumlin Field. It has been suggested that the most recent glacial period, the Wisconsin Glaciation, covered this area between 110,000 and 10,000 years ago. The surrounding topography is believed to be the result of the advance and retreat of this glacial period (Gravenor, 1957). The general topography of the watershed is defined in the Soil Survey of Peterborough County (O.M.A.F., 1981) as being moderately to gently sloping and exceedingly to slightly stony. The elevation ranges 75 metres through the Indian River Watershed, with the highest altitude of 275 metres above sea level occurring at Hall Glen in Dummer Township. The lowest altitude recorded in the watershed occurs around the Village of Keene in Otonabee Township and is 200 metres above sea level.

The northern third of the watershed is identified as the Dummer Recessional Moraine, and is characterized by low, stony knobs and relatively straight ridges which lie transverse to the direction of the ice movement. The

moraine is shallow with ridges averaging 7.5 metres in height, and the glacial till is characterized by blocks of limestone, angular fragments and the presence of many Precambrian rocks (Chapman and Putnam, 1973). The underlying bedrock is sedimentary limestone, mostly of the Black River Group, but also including some of the overlying Trenton.

The Indian River Watershed south of the Village of Warsaw is part of the Peterborough Drumlin Field. This section of the drumlin field is comprised mainly of depositional drumlins - those which are formed of till or mixtures of till and minor amounts of stratified material. Typically these drumlins are less than 1.6 km long and 0.5 km wide with an average height of 23 metres (Chapman and Putnam, 1973). They are closely spaced, averaging 2 per square km, and are composed of highly calcareous till. The underlying bedrock of the Peterborough Drumlin Field is mainly Trenton limestone and is highly fossiliferous and easily disintegrated.

The Soil Survey of Peterborough County (O.M.A.F., 1981) indicates that Dummer loam and Rockcroft sandy loam are the predominant soil series in the northern part of the watershed. Both of these soil types are well drained, and after extensive stone removal have produced good to fair

crops of hay and oats. Most of the agricultural land of Dummer loam, however, is used for pasture.

About two-thirds of the moraine has been identified by the Canada Land Inventory (1967) as being Class 6 soils on a scale of 1 to 7. Stoniness, shallowness to bedrock and rugged terrain are the main agricultural limitations.

Farmington loam is the predominant soil series along the length of the main channel. It is typically less than 30 cm of loam underlain by limestone rock and is well drained.

The soil series of Otonabee loam and Bondhead sandy loam occupy the majority of the lower watershed. Both of these soils are calcareous, stony and well drained. Otonabee loam is often shallow in nature, whereas the Bondhead sandy loam has a deeper profile and is sandier, making it a more preferred agricultural soil than the similar Otonabee loam (Chapman and Putnam, 1973).

2.2 Land Use

Current land use patterns in the Indian River Watershed are a reflection of its physical characteristics. The Indian River watershed encompasses an area of 186 sq. km of which 129 sq. km (69%) are agricultural land, 41 sq. km (22%) are

woodland, 12 sq. km (6%) are scrub land and marsh and 5 sq. km (3%) are urban areas (O.R.C.A., 1983).

Agriculture is by far the largest land use category. Beef farming is the predominant type of farm operation, followed to a much lesser extent by dairy, swine and poultry, respectively. Most farming operations grow cash crops in addition to raising livestock. 4.37 sq. km of the watershed is tile drained, this being almost exclusively in Otonabee Township.

Of the woodlands in the watershed 26 sq. km are wet wooded and 15 sq. km are dry wooded, with eastern white cedar (Thuja occidentalis) and sugar maple (Acer saccharum) being the dominant species. These areas are generally situated on lands unsuitable for agricultural production. Most of the woodlots are small and privately owned.

There are four small urban centers in the Indian River Watershed; the villages of Warsaw, Douro, Lang and Keene. The Village of Warsaw is located on the Indian River in Dummer Township and has a population of approximately 500. The Village of Douro is located in Douro Township and the population is estimated to be 60. Lang and Keene are situated on the Indian River in Otonabee Township, and their

populations are estimated at 75 and 500, respectively. There are also a number of rural residential homes dispersed throughout the watershed.

2.3 The Watercourse

The Indian River originates at Gilchrist Bay Dam on Stony Lake, flows through Dummer Lake and continues southward for 45 km where it empties into Rice Lake (Fig. 1). The average gradient is 0.9 m/km and the elevation at the mouth of the river is 200 m above sea level (O.R.C.A., 1983). The Indian River ranges in depth from approximately 10 cm to 5 m and the average width is 25 m. The river bottom is composed primarily of flat slabs of limestone bedrock.

Transecting the main watercourse at several points is a series of rock weirs and dams. Generally these are small obstructions and do not cause a substantial interruption in flow. Two major dam sites exist on the southern part of the river. These generate the power for the historic Hope Sawmill and Lang Gristmill owned by the Otonabee Region Conservation Authority.

The Indian River supports a good warm water fishery composed primarily of Largemouth Bass (Micropterus salmoides), Smallmouth Bass (Micropterus dolomieu), Rock Bass

(Ambloplites rupestris), Yellow pickerel (Stizostedion vitreum) and Muskellunge (Esox masquinongy).

Two resort areas are located on the main watercourse. Situated in the Village of Keene is the Indian River Lodge, a private establishment which caters mainly to sports fishermen. Upstream at Highway 7 is the Riverside Park and Campground, also a privately owned resort. In addition to these there are several private cottages along the river and surrounding Dummer Lake. Dummer Lake itself supports approximately 300 cottages and permanent dwellings.

The Conservation Authority recognizes the Indian River as a recreational canoe route which offers many opportunities to those who are interested in viewing or photographing wildlife, fishing or enjoying the historic sites and beaches.

2.4 The Beaches

The Indian River Beaches study is focused specifically on four beach areas: the Warsaw Caves, Hope Mill and Lang Mill Beaches owned by the Otonabee Region Conservation Authority, and the Douro Park Beach, part of a recreational complex owned by the Township of Douro.

The Warsaw Caves Beach is located in the northern part of

the watershed (Fig. 1). It is a well treed area with an open, grassy section at the north end of the beach. There is very little sand present, and the river bottom is exposed slabs of limestone bedrock. Beach dimensions and capacity are recorded in Table 1. Since this beach is part of the Warsaw Caves Conservation Area there is an abundance of associated facilities and recreational opportunities (Table 2). The land surrounding the Warsaw Caves Beach, outside of the Conservation Area, consists mainly of agricultural land and private woodlots.

Douro Park (Fig. 1) has beaches on both sides of the river. They are surrounded by large open grassy areas interspersed with trees and other vegetation. The river bottom is composed of flat slabs of limestone bedrock. Surrounding the beaches, in the park itself, are well maintained baseball diamonds and soccer fields. Beach dimensions and capacities are recorded in Table 1; associated facilities can be found in Table 2. Land use in the vicinity of Douro Park is typically agricultural with an abundance of wet woodland.

The Hope Mill Conservation Area, located in Otonabee Township (Fig. 1), also has beaches on both sides of the river. The river widens here as a result of the dam causing

Table 1 - Beach Capacities (based on standards as defined in T.O.R.P.S. 1975)

<u>BEACH</u>	<u>DIMENSIONS</u> (m)	<u>CAPACITY</u>
Warsaw Caves	Beach Length 30.5	56
	Dry Beach 8	
	Wet Beach 25	
Douro Park West	Beach Length 69	72
	Dry Beach 4.5	
	Wet Beach 24	
Douro Park East	Beach Length 23	48
	Dry Beach 9	
	Wet Beach 10.5	
Hope Mill West (day-use)	Beach Length 56	179
	Dry Beach 14	
	Wet Beach 30.5	
Hope Mill East (campground)	Beach Length 55	77
	Dry Beach 6	
	Wet Beach 6	
Lang Mill	Beach Length 44	62
	Dry Beach 6	
	Wet Beach 14	

Table 2 - Associated Facilities for the Indian River Beaches

<u>Facilities</u>	<u>Warsaw Caves</u>	<u>Douro Park</u>	<u>Hope Mill</u>	<u>Lang Mill</u>
Vault Toilets	X	X	X	X
Change House	X	X	X	
Picnic Tables	X	X	X	X
Picnic Shelter	X		X	
Barbecues	X			
Drinking Water	X	X	X	X
Refreshment Booth				X
Boat Launch	X			
Docking Facilities	X			
Canoe Rental	X			
Parking Area	X	X	X	X
Family Camping	X		X	
Group Camping	X		X	
Firewood	X		X	
Hydro Service		X	X	
Historic Site			X	X
Outdoor Education	X			
Sports Facilities		X		
Trails	X		X	
Dam			X	X

a build-up of sediment and more excessive weed growth than at the upstream beaches. The west beach is surrounded by a large, open, grassy area, whereas the east beach is more enclosed, with trees to separate it from adjacent campsites. Beach dimensions and capacities can be found in Table 1 ; associated facilities are recorded in Table 2. The surrounding land use is primarily agricultural with some woodlands.

Approximately 1.5 km downstream of Hope Mill is the Lang Mill Conservation Area beach (Fig. 1). The Lang Beach has a heavily sedimented and weedy bottom. Beach dimensions and capacities are recorded in Table 1. Directly across the river from the Lang Beach is the David N. McIntyre Memorial Park. As a result of the adjacent Century Village, Lang Beach has many associated facilities (Table 2) for visitors. Surrounding land use is primarily residential and agricultural.

3.0 PROBLEMS ASSOCIATED WITH BEACH CLOSURES

Elevated bacterial levels at public beaches along the Indian River have led to increased numbers of beach closures in recent years. These beaches are posted by the Peterborough County-City Health Unit when the Ontario Ministry of Health guideline of 100 fecal coliforms (FC) per 100 ml of water (10-sample geometric mean over a two day period) is exceeded. County beaches are tested by the Health Unit twice weekly unless there is a posting, after which testing is on a daily basis until the beach is reopened for swimming.

High bacterial levels at rural beaches may be as a result of inputs from a number of sources. Agricultural sources include: unrestricted livestock access to a stream, runoff from feedlots and manure storage areas, manure handling practices and disposal of milkhouse wastes. Other common sources of bacterial inputs to rivers in rural areas are faulty septic systems, precipitation, inputs from natural streams, and wildlife. Land-use practices adjacent to a river or stream are a major factor in determining the extent of water quality degradation in a watercourse (Faust and Goff, 1977; Kunkle, 1970).

As a result of the importance of land-use activities within

a watershed, the landowner contact program became a crucial component of the Indian River study. During 1986, large property owners adjacent to a watercourse, primarily farms, were asked to answer a questionnaire on land-use practices. In 1987 the emphasis was on small properties with less than 10 acres. These property owners, a large proportion of which were cottagers on Dummer Lake, were asked questions about their septic systems and water supply.

3.1 Beach Closures 1985 - 1987

Beach closures at the four beach areas on the Indian River for the 1985-1987 period are shown in Table 3 and Figure 2. There was a substantial decrease in beach closures during 1987 at three out of the four beaches. Closures at Warsaw Caves were 71% lower, at Douro Park they were down 44%, and at Hope Mill the beaches were closed 57% less in 1987 than in 1986. In contrast to the other beach areas, Lang Mill beach was closed 38% more in 1987. Overall, closures were 34% lower in 1987 compared with 1986. This corresponded with bacterial levels for main river stations which were an average of 37% lower in 1987.

The overall reduction in beach closures in 1987 appears to be largely the result of less rainfall during the 1987 season. Precipitation levels during the 1987 bathing season

Table 3: Number of Days the Indian River Beaches Were Closed From 1985 - 1987.

BEACH CLOSINGS

NUMBER OF DAYS CLOSED

BEACHES/YEAR	MAY	JUNE	JULY	AUGUST	TOTAL
Warsaw Caves					
1987	0	1	1	7	9
1986	0	11	13	7	31
1985	0	0	14	1	15
Douro Park					
1987	1	3	4	7	15
1986	0	11	4	12	27
1985	0	0	14	8	22
Hope Mill					
1987	0	2	0	4	6
1986	0	8	3	3	14
1985	0	0	13	1	14
Lang Mill					
1987	0	0	9	7	16
1986	0	4	4	2	10
1985	2	0	14	19	35

DATA FROM PETERBOROUGH COUNTY-CITY
HEALTH UNIT

BEACH CLOSURES - 1985-1987

INDIAN RIVER BEACHES

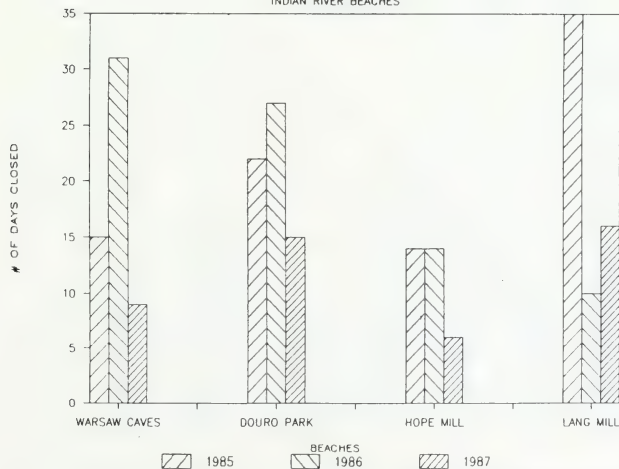


Figure 2: Number of Days the Indian River Beaches Were Closed From 1985 - 1987.

(June 1 - August 31) were 9.5% less than what would be expected during a normal year in this region, and 30.5% less than the levels recorded in 1986 (Fig. 3).

The increase in beach closures at Lang in 1987 appears to be caused by factors other than rainfall. Rainfall levels, especially during July, did not correspond with the increased bacterial levels. Other factors responsible may be a larger number of cattle watering just upstream of the beach in 1987, as well as a population of about 20 waterfowl which were present at the beach during the bathing season the same year.

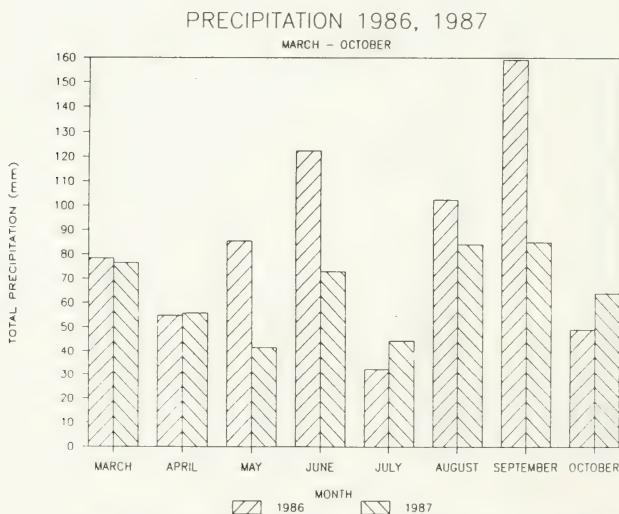


Figure 3: Total Precipitation (mm) from March - October, 1986 and 1987. Data Obtained from the Environment Canada Weather Office, Peterborough, Ontario.

4.0 WATER MONITORING PROGRAM

4.1 METHODS

4.1.1 Water Quality Monitoring

Bacterial Sampling =====

Preliminary work prior to the 1986 field season involved gathering of background data and analysis of air photos to assist in determining the location of sampling sites. Tributaries, erosion sites, dams, and land-use practices which appeared to be contributing to water quality contamination were noted and then field checked. Sampling locations during the first year of study were established at regular intervals along the main river, at points which were easily accessible. Stations were situated in conjunction with the four beach areas as well as upstream and downstream of the Villages of Warsaw, Keene and Lang, to assess any effects these urban areas might be having on water quality. Sampling stations were also set up near the mouth of all tributaries entering the Indian River, and at any points which appeared to be potential problem areas. In April 1987, the Indian River watershed was flown to obtain air photography of problem areas. During 1987 the location of stations was similar, although there was only one sampling point situated at the mouth of each tributary, and some of the main river stations were changed to better evaluate problem areas identified in 1986.

The collection of water samples for bacterial analysis in 1987 took place from March 23 to October 5 at 36 stations from the Gilchrist Bay Dam at Stony Lake south to the Village of Keene (Fig. 1). Samples were taken once/month in March and October, twice/month in April and September and weekly from May through August. Four tributaries monitored by Stations 6, 15, 24 and 28 were not included in the analyses since they all stopped flowing by June 15.

Some additional dry weather sampling was also done weekly along two problem tributaries in the watershed. These were the Cameron Creek tributary monitored on a regular basis at Station 34, and the Keene Village tributary normally monitored at Station 36. Six additional stations were sampled on Cameron Creek primarily in the vicinity of a problem farm identified in 1986. On the Keene Village tributary five extra stations were sampled weekly to assess the exact sources of some urban discharges to the creek. The additional monitoring on both tributaries took place from late May until mid-July, when low flows prevented further sampling.

Rain event sampling was done three times during the 1987 season - in June, July and September to concentrate on problem areas identified in 1986. During each event samples

were taken once per day for three consecutive days.

A preliminary assessment of bacterial contributions from sediments at the bathing beaches was also undertaken. Bacterial samples were taken before and after agitation of river bottom sediments at the four beach areas once per month from April to October.

Detailed mapping of the four beach areas was also completed. Transects were done at 1.5m intervals and to a 1.5m depth, every 5 m along the shoreline. River bottom sediment type and the percent and type of vegetation were noted.

The bacterial samples were taken to the Regional Public Health Laboratory in Peterborough for analyses. Samples were analyzed for fecal coliforms and Pseudomonas aeruginosa. Until early July all samples were analyzed for P. aeruginosa. For the remainder of the season this species was only analyzed in samples from those stations where fecal coliforms were consistently high. Selected samples were analyzed for Escherichia coli in July, as well as all samples for the October run to provide data on how the frequency of this indicator compared with fecal coliform counts for the river.

Chemical Sampling =====

Sampling for chemical analyses in 1987 was undertaken at 21 locations along the main river and tributaries. These samples were taken once/month in March, April and October and twice/month from May to September.

The chemical samples were analyzed by the Ministry of the Environment laboratories in Rexdale for the following parameters:

Conductivity	Total Kjeldahl Nitrogen
pH	Ammonium
Chloride	Nitrates
Particulate Residue	Nitrite
Turbidity	
Total Phosphorus	
Dissolved Reactive Phosphorus	

4.1.2 Water Quantity Monitoring

Spot flows and stage recordings were taken weekly at 18 locations throughout the watershed. Spot flows were taken with a Marsh-McBirney flow meter (Model 201) at all stations on the main river and tributaries which were shallow enough to wade across. Discharges were then calculated using spot flows and water depths.

4.1.3 Data Analysis

Geometric means were calculated for the bacterial data and

arithmetic means for the chemical and discharge data. Correlation analysis was used to assess the relationships between various bacterial and chemical parameters. Significant relationships were determined to be those with a 95% level of significance or greater.

The bacterial data were separated into dry and wet samples. Dry samples were those taken without rainfall in the previous 48 hours. There were 22 days of dry weather data and 33 days of wet weather data. Bacterial data with values of "greater than" or "less than" were dealt with as per methods described in Appendix A.

Theoretical mass balance equations were calculated to estimate increases in bacterial concentrations as a result of three discharges entering the main river. It must be recognized, however, that these equations do not take into account bacterial die-off rates, bacterial sedimentation rates, or the potential bacterial input between those stations being compared.

4.2 RESULTS AND DISCUSSION

4.2.1 Water Quality Monitoring

Bacterial Data =====

Bacterial counts for all stations and their geometric means

are listed in Appendix A. Bacterial data for the entire season (March - October) as well as for the bathing season only (June - August), were graphed (Figs. 4, 5).

These figures show the separation of wet and dry data as well as the combined values for each station. Overall there was very little difference between levels for the entire season versus the bathing season, with the exception of slightly higher bacterial concentrations for the tributaries during the bathing season.

The wet weather bacterial levels were an average of 75% greater than the dry weather concentrations for the March to October periods in 1987. It is these wet weather levels which were likely responsible for seasonal bacterial concentrations exceeding 100 FC/100 ml in some portions of the watercourse. In the northern half of the watershed as far south as Guerin, bacterial concentrations (combined data - geometric means) were below the M.O.E Water Quality Objective of 100 FC/100 ml. In a 6.5 km stretch of the river from Guerin to approximately 3 km south of Jermyn at Highway 7 (Stations 19-26) bacterial concentrations exceeded 100 FC/100 ml. Bacterial levels decreased from north of Hope Mill downstream to Lang Mill where they increased again in the lower section of the river. At the Keene bridge

MEAN BACTERIAL CONCENTRATIONS

INDIAN RIVER WATERSHED - MARCH - OCT.

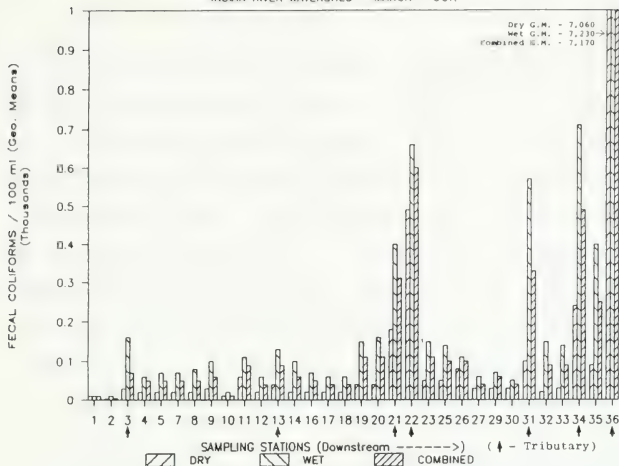


Figure 4: Mean Bacterial Concentrations in the Indian River Watershed Using Wet, Dry and Combined Data for the 1987 Sampling Season (March 23 - October 5).

MEAN BACTERIAL CONCENTRATIONS

INDIAN R WATERSHED-BATHING SEASON

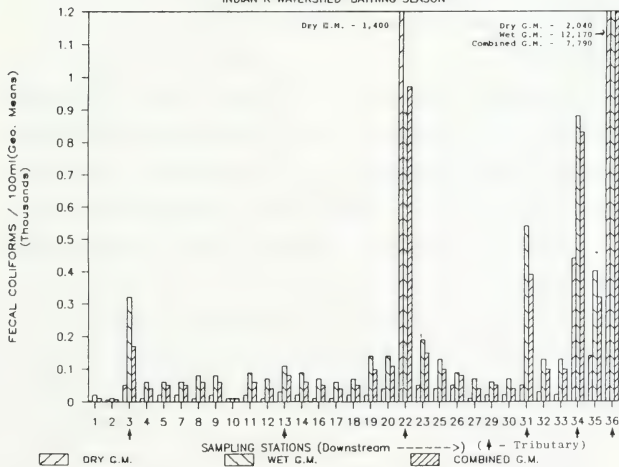


Figure 3: Mean Bacterial Concentrations in the Indian River Watershed Using Wet, Dry and Combined Data for the 1987 Bathing Season (June 1 - August 31).

(Station 35) the bacterial geometric mean for the entire season was 250 FC/100 ml and for the bathing season only it was 320 FC/100 ml. The elevated bacterial counts between Stations 19 and 26 appear to be primarily the result of farming practices along both the main channel and tributaries entering the river in this region. There are several areas of unrestricted cattle access to these watercourses. The high bacterial concentrations in the main river at Keene may be due partially to high fecal coliform counts from Cameron Creek (Station 34), which enters the river about 1.5 km north of the village. Station 34 had a fecal coliform geometric mean of 490 FC/100 ml for the entire season and 830 FC/100 ml for the bathing season only. There may also be some contribution from within the Village of Keene.

Figure 6 shows a comparison of main river bacterial concentrations for 1986 and 1987. Although there was generally the same pattern progressing downstream in both years, bacterial levels in 1986 were an average of 37% higher. In 1986 the majority of main river stations had counts exceeding the M.O.E. water quality objective. This substantial difference in bacterial concentrations between the two years appears to be related to the much higher rainfall levels in 1986.

Bacterial concentrations for each day sampled at the four beach areas during the bathing season in 1987 are shown in Figures 7-10. These figures are based on 10 sample geometric means obtained from the Peterborough County-City Health Unit. Daily precipitation for the same time period is depicted in Figure 11. For Warsaw Caves, Douro Park and Hope Mill beaches high fecal coliform levels corresponded in most cases with significant amounts of rainfall (>10 mm) within the previous 48 hours. Only two days of substantial rainfall (June 22 and August 17) did not affect bacterial levels at the beaches. In the reverse situation the northern three beaches all had fecal coliform concentrations greater than or equal to 100/100 ml on June 4, without a significant amount of precipitation in the previous 48 hours. These cases of course may be in part due to local variations in rainfall levels. At Lang Mill beach high bacterial concentrations from July 16-30 were not related to rainfall events. As discussed previously the high incidence of beach closures at Lang in 1987 appeared to be more a result of increased cattle access since 1986, and a resident population of ducks and geese.

Rain Event Sampling

Rain event sampling was carried out three times during the sampling season - in June, July and September. The June

BACTERIAL LEVELS 1986,1987

INDIAN RIVER - MAIN CHANNEL

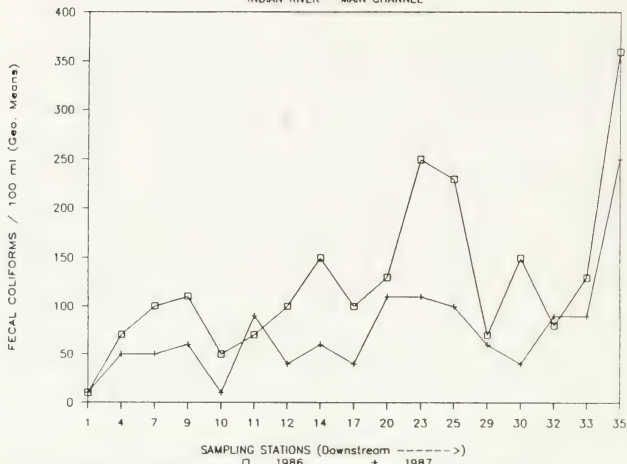


Figure 6: Mean Bacterial Concentrations at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

BACTERIAL CONCENTRATIONS

WARSAW CAVES BEACH - JUNE 1-AUG 31,1987

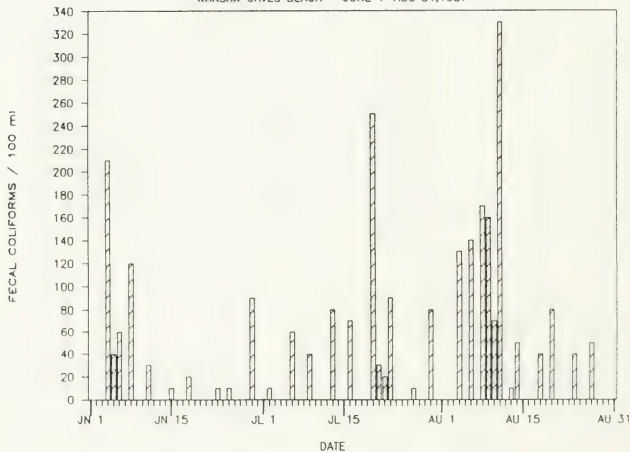


Figure 7: Daily Bacterial Concentrations at the Warsaw Caves Beach for the 1987 Bathing Season.

BACTERIAL CONCENTRATIONS

DOURO PARK BEACH - JUNE 1-AUG. 31, 1987

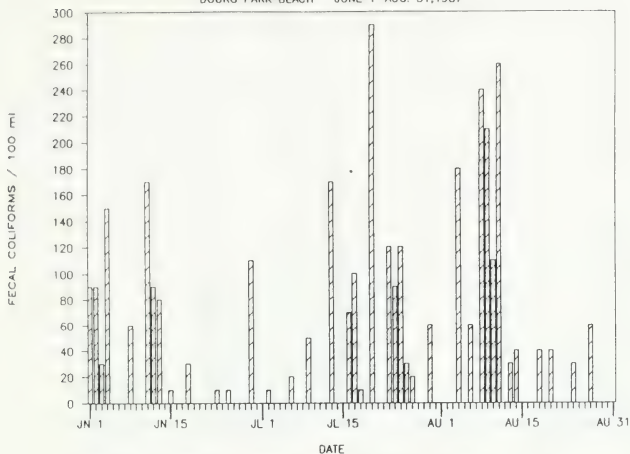


Figure 8: Daily Bacterial Concentrations at the Douro Park Beach for the 1987 Bathing Season.

BACTERIAL CONCENTRATIONS

HOPE MILL BEACH - JUNE 1-AUG. 31, 1987

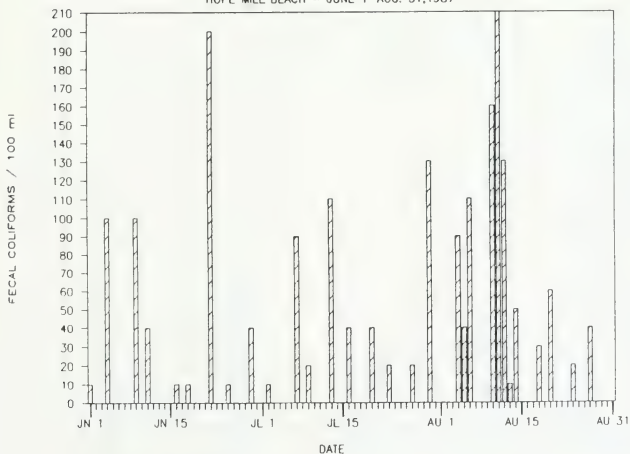


Figure 9: Daily Bacterial Concentrations at the Hope Mill Beach for the 1987 Bathing Season.

BACTERIAL CONCENTRATIONS

LANG MILL BEACH - JUNE 1-AUG. 31, 1987

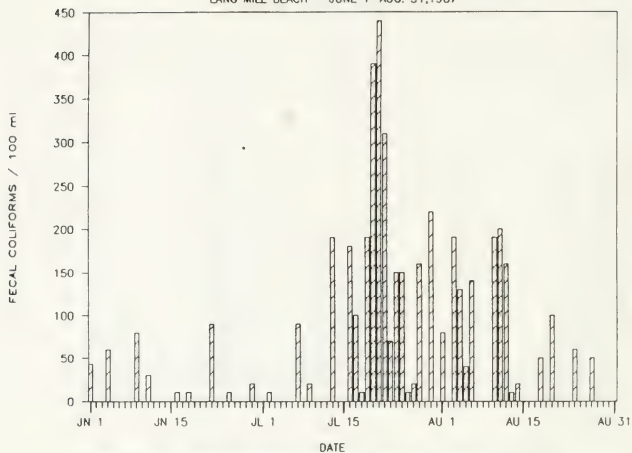


Figure 10: Daily Bacterial Concentrations at the Lang Mill Beach for the 1987 Bathing Season.

DAILY PRECIPITATION

JUNE 1 - AUGUST 31, 1987

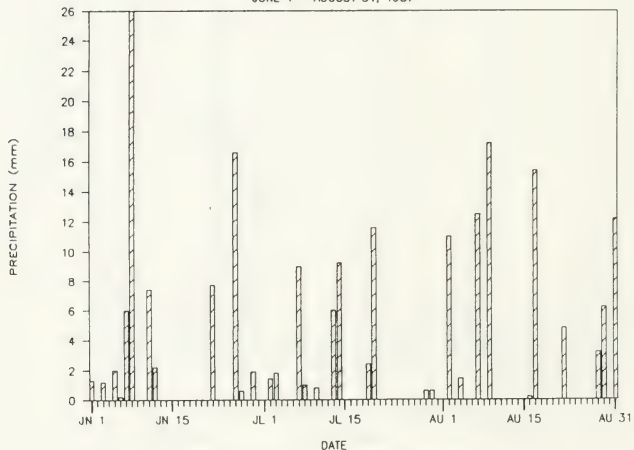


Figure 11: Daily Precipitation (mm) for the 1987 Bathing Season.

event was not considered in the data analysis since the total rainfall was less than 10 mm. Graphs of bacterial concentrations for the July and September rain events are shown in Figures 12, 13. For the July event there was 15.2 mm of rain starting late in the day prior to the first day of sampling and ending the following day. Figure 12 shows that for main river stations in the northern portion of the watershed bacterial concentrations decreased over the three day sampling period. There was little pattern for the southern half of the river. The high fecal coliform levels at Stations 19 and 20 are a further indication of a severe farm pollution problem just upstream. The high bacterial count at Station 35 on the first day of sampling (2100 FC) also indicates a runoff related problem. This elevated count at Keene may be largely a result of high bacterial levels which occurred in Cameron Creek (Station 34-4900 FC) on the same day. There are several areas along Cameron Creek which have a high potential to contribute bacteria to the watercourse, primarily through direct cattle access and runoff from manure storage areas.

During the September rain event there was 27.8 mm of rain which occurred entirely on the first day of sampling. Figure 13 shows that the tendency for bacterial levels was to peak on the second day of sampling for the majority of

RAIN EVENT BACTERIAL CONCENTRATIONS

INDIAN RIVER WATERSHED

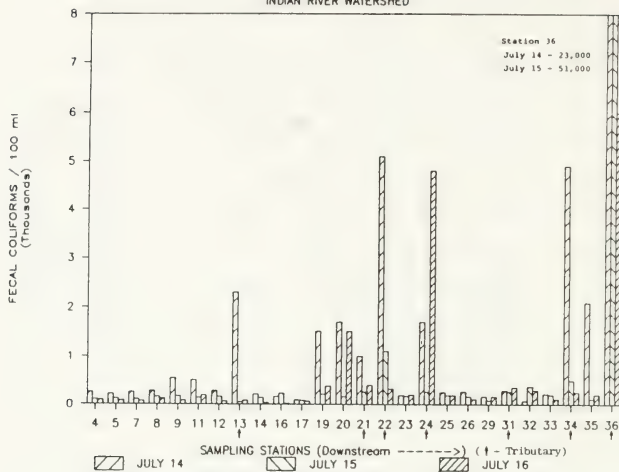


Figure 12: Bacterial Concentrations for the July 14, 15 and 16, 1987 Rain Event in the Indian River Watershed.

RAIN EVENT BACTERIAL CONCENTRATIONS

INDIAN RIVER WATERSHED

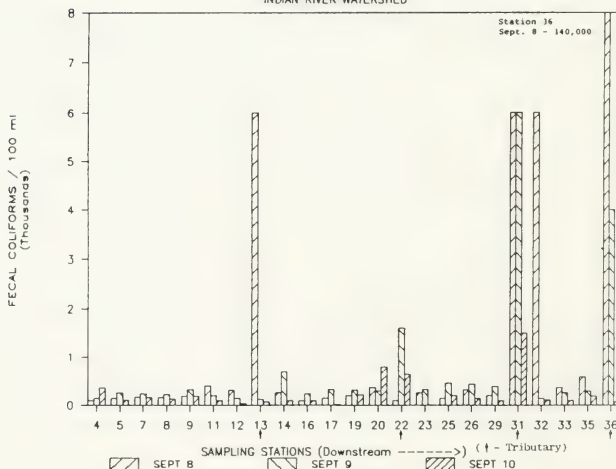


Figure 13: Bacterial Concentrations for the September 8, 9 and 10, 1987 Rain Event in the Indian River Watershed.

stations on the main river. As with the July event bacterial levels in the main river tended to peak approximately 24 hours after the rainfall started. Contrary to most stations Station 32 (Lang Mill beach) peaked with a very high fecal coliform count (>6,000) on the first day of sampling. This may be indicative of a very rapid runoff of beach sediments containing a high bacterial content due to the resident waterfowl population. Although bacterial levels were generally higher for the September rain event, which corresponds to the higher amount of precipitation, the counts at some stations such as 19, 20 and 35 were much lower. This may be partly the result of differences in runoff characteristics at these areas during the two rain events. Kunkle (1970) noted that the size of the runoff area for a particular channel reach depended on antecedent moisture and other factors causing the area to vary greatly from one storm to the next, even when precipitation amounts are identical.

Bacterial Sediment Assessment

The results of the bacterial sediment sampling at the four beach areas are shown in Table 4 and Figures 14-17. Seyfried and Harris (1986) found from their studies on the Humber River and Black Creek that during dry weather, at

Table 4: Comparison of Bacterial Data for Disturbed vs. Undisturbed Beach Samples At the Indian River Beaches, April - October, 1987.

MONTH SAMPLED	Fecal Coliforms / 100 ml H ₂ O									
	WARSAW		DOUPO		HOPE		LANG			
	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed		
April	50	40	20	30	40	30	10	< 10		
May	80	50	60	50	110	150	50	80		
June	* < 10	* < 10	* 10	* 10	* 30	* 20	* 10	* 10		
July	< 10	> 6000	< 10	60	10	100	50	400		
August	* 30	* 110	* 30	* 80	70	30	180	200		
September	* 170	* 50	* 130	* 50	* 100	* 60	* 3800	* 390		
October	100	80	30	100	50	130	60	240		

* - Wet Weather Sample

BACTERIAL SEDIMENT SAMPLES

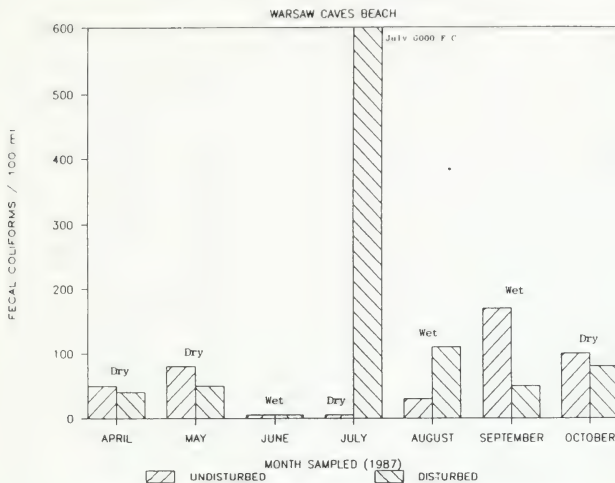


Figure 14: Bacterial Concentrations Before and After Disturbing Bottom Sediment at Warsaw Caves Beach, 1987.

BACTERIAL SEDIMENT SAMPLES

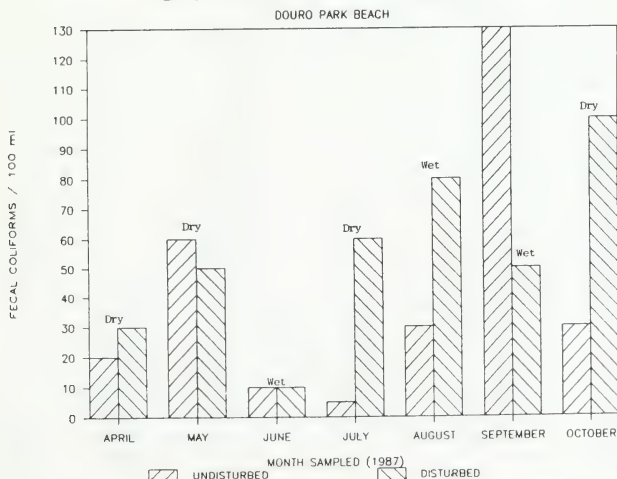


Figure 15: Bacterial Concentrations Before and After Disturbing Bottom Sediment at Douro Park Beach, 1987.

BACTERIAL SEDIMENT SAMPLES

HOPE MILL BEACH

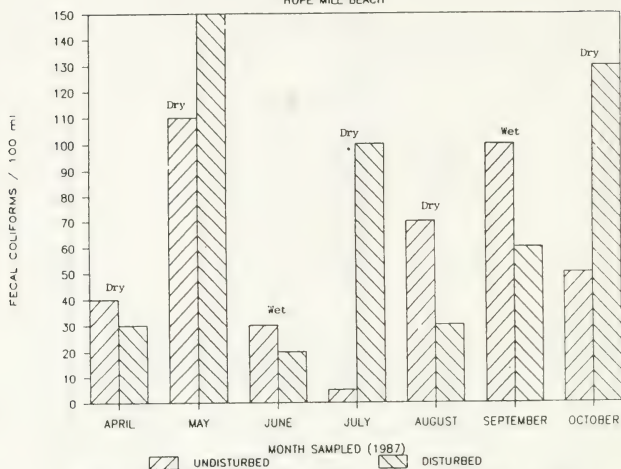


Figure 16: Bacterial Concentrations Before and After Disturbing Bottom Sediment at Hope Mill Beach, 1987.

BACTERIAL SEDIMENT SAMPLES

LANG MILL BEACH

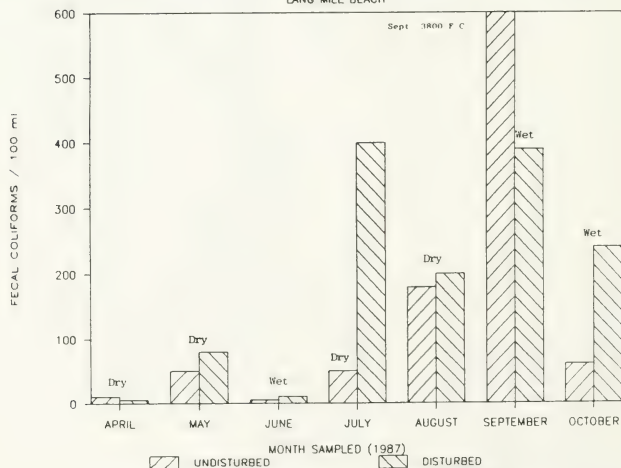


Figure 17: Bacterial Concentrations Before and After Disturbing Bottom Sediment at Lang Mill Beach, 1987.

locations with high point source loadings, samples taken from the water column after sediment agitation showed higher fecal coliform counts than samples taken before agitation. They noted that during wet weather, bacterial densities were usually higher than those induced by dry weather sediment agitation. For dry weather samples taken during our bacterial sediment sampling the event of higher fecal coliform counts in disturbed versus undisturbed samples for the four beaches are: Warsaw - 1 of 4; Douro - 3 of 4; Hope - 3 of 5; and Lang - 4 of 5. Even though these sample sizes are very small, it appears that Lang beach has the highest potential to experience elevated bacterial levels with agitation of bottom sediments, whether the cause is swimmers or other factors such as storm events. This higher potential may be due in part to the type of river bottom sediments present at this beach. The detailed beach mapping (Appendix B) showed that Lang had a much higher percentage of silt and organic deposits than the other beach areas. Seyfried and Harris (1986) noted that the smallest inorganic particles such as clays and silts make the best adsorbents for bacteria since, in a given volume, they provide a greater surface area for absorption than larger particles such as sand. Therefore the finer grained sediments at the Lang beach may be trapping a larger percentage of bacteria which are then resuspended in the water column when disturbed.

The Warsaw beach is the only area that did not show higher bacterial levels after disturbance of sediments. This is likely due to the small percentage of coarse grained sediment overlying the flat limestone bedrock at Warsaw.

Specific Bacterial Indicators

The bacterium Pseudomonas aeruginosa is most often found in bathing areas impacted by human activity. It is known to cause skin rashes and eye infections and is the primary organism associated with ear infections. Levels of P. aeruginosa in Ontario recreational waters range from 0/100 ml to greater than 100/100 ml, with the median level typically less than 1/100 ml (M.O.E., 1984).

During 1987 levels of P. aeruginosa were usually less than 10/100 ml at all stations on the Indian River except at Station 36, which monitored the Keene Village tributary. In this tributary the levels of the bacterium ranged from less than 10/100 ml to 650/100 ml, with a geometric mean concentration of 10/100 ml. This tributary also showed very high fecal coliform counts. In 1987 Station 36 had a combined geometric mean for the entire sampling season of 7170/100 ml. For the other stations sampled weekly on this tributary the highest fecal coliform geometric mean was

35,500/100ml. Because of the high bacterial levels in this tributary results were reported to the Peterborough County-City Health Unit. Their investigation into the causes of these levels led to the subsequent cleanup and/or replacement of septic systems at local businesses and private residences.

The fecal coliform geometric means for stations along Cameron Creek (Stations 34-34F) ranged from 490/100 ml to 1960/100 ml for dry and wet data combined. P. aeruginosa levels were generally less than 10/100 ml. These high tributary counts appear to be the result of farming practices in several areas along the creek. The problems primarily consist of unrestricted cattle access to the stream and runoff from feedlots and manure storage areas.

Escherichia coli are bacteria which inhabit the gastrointestinal tracts of man and other warm-blooded animals. They have been found to comprise 90-100% of all coliforms in the feces of domestic animals. They are rarely found growing in natural environments and can therefore be used as specific, reliable indicators of fecal contamination of water (M.O.E., 1984).

Analysis for fecal coliforms and E. coli (Appendix C) in

October showed that E. coli ranged from 7% to 100% of the fecal coliforms, with a mean of 70% for the watershed.

Theoretical Mass Balance Equations

The calculation of theoretical mass balance equations (Appendix D) showed that the tributary monitored at Station 22 should be having only a slight effect on the increase of bacterial levels in the main river. Station 20 upstream on the main river had a seasonal geometric mean of 110 FC/100 ml and the predicted value downstream was 120 FC/100 ml. The actual downstream value at Station 23 was a geometric mean of 110 FC/100 ml.

The mass balance equation calculated for the tributary monitored at Station 31 showed that this creek should not be affecting bacterial water quality downstream. The upstream value at Station 30 was a geometric mean of 40 FC/100 ml as was the calculated downstream concentration. The actual downstream concentration from the 1987 sampling season at Station 32 (Lang Beach) was 90 FC/100 ml (G.M.). This area, however, was about 1 km downstream from where the tributary discharged to the main river, and as mentioned previously had a number of other bacterial inputs as a result of unrestricted cattle access and a local waterfowl population.

The tributary monitored at Station 34 appeared to be having only a slight effect on increased bacterial levels in the main river. The calculated downstream concentration of 120 FC/100 ml was only slightly higher than the geometric mean value of 100 FC/100 ml at Station 33 upstream. The actual downstream bacterial concentration at Station 35 (Keene bridge) was 250 FC/100 ml (G.M.). This would indicate that urban bacterial inputs from the Village of Keene are contributing to these high counts at Station 35.

Chemical Data
=====

Phosphorus

The seasonal means of all chemical parameters analyzed are shown in Table 5 and Appendix E and their correlations in Appendix F. Means are calculated based on 11 sample runs. Mean phosphorus concentrations for all stations sampled in 1987 are illustrated in Figure 18. Total phosphorus levels exceed the M.O.E. guideline of 0.03 mg/l at one main river station (35) and at five tributary stations (21, 22, 31, 34 and 36). In 1986 total phosphorus did not exceed the guideline at any main river station (Fig. 19). Except for Stations 7 and 35 main river levels during both years were similar.

Table 5: Means of Chemical Parameters at Indian River Sampling Stations, 1987.

STATION	CONDUCTIVITY	pH	CHLORIDE	RESIDUE	TURBIDITY	PHOSPHORUS	PHOSPHATES	NITROGEN TOT.	AMMONIUM TOTAL	NITRATES TOT.	NITRITE
	cmho/cm @ 25C		mg/l	PARTICULATE	Formazin U.	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	199.36	8.2	5.8	1.98	1.23	0.015	0.0035	0.373	0.046	0.055	0.0035
2	206.64	8.28	5.73	1.79	1.81	0.012	0.001	0.3668	0.04	0.05	0.0023
3	347.8	8.16	3.84	6.46	2.52	0.021	0.0016	0.271	0.011	0.088	0.009
4	737.36	8.21	5.48	2.15	1.6	0.016	0.002	0.341	0.03	0.053	0.0037
7	240.67	8.18	5.49	5.78	2.17	0.03	0.0089	0.3852	0.032	0.064	0.0034
11	251.25	8.27	6.33	2.41	1.87	0.014	0.0022	0.3842	0.038	0.083	0.0029
12	248.42	8.22	5.73	4.45	1.39	0.0154	0.0028	0.3375	0.02	0.085	0.0033
13	851.00	8.13	13.2	4.84	2.17	0.03	0.0074	0.782	0.061	0.029	0.0037
14	257.33	8.18	6.17	3.8	2.15	0.0177	0.0026	0.3617	0.037	0.068	0.0054
20	258.67	8.2	6.12	3.48	2.88	0.0158	0.0024	0.3583	0.047	0.058	0.004
21	898.44	8.21	15.44	5.88	4.17	0.0382	0.0123	0.86	0.034	0.052	0.0182
22	532.4	8.17	18.78	18.29	5.55	0.1448	0.0451	0.986	0.04	0.238	0.071
23	265.17	8.18	6.24	6.31	3.11	0.0236	0.006	0.4463	0.04	0.051	0.0051
31	426.11	8.03	15.55	6.17	3.11	0.0374	0.0108	0.9422	0.04	0.054	0.0181
33	266.08	8.31	6.92	4.12	2.51	0.0184	0.0041	0.3927	0.018	0.05	0.0045
34	894.33	8.43	18.29	6.14	3.14	0.1371	0.0586	0.8589	0.078	0.271	0.0772
35	281.27	8.21	8.57	6.35	4.88	0.0332	0.011	0.1882	0.024	0.15	0.0037
36	878.63	8.27	94	17.89	5.22	0.2886	0.157	0.4125	0.079	1.424	0.0825

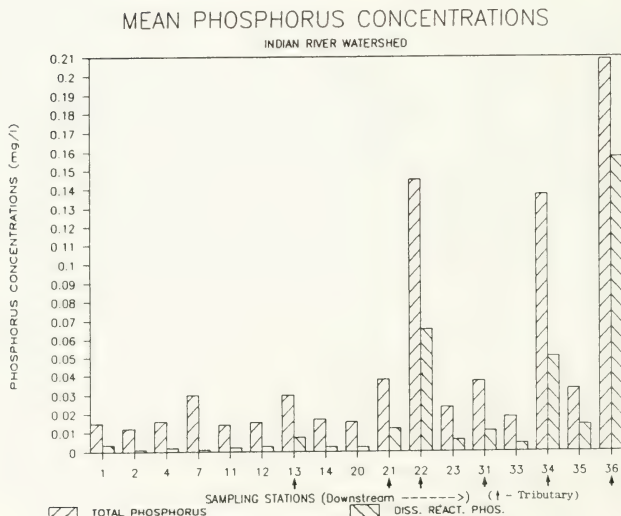


Figure 18: Mean Phosphorus Concentrations in the Indian River Watershed at 1987 Sampling Stations.

TOTAL PHOSPHORUS 1986,1987

INDIAN RIVER - MAIN CHANNEL

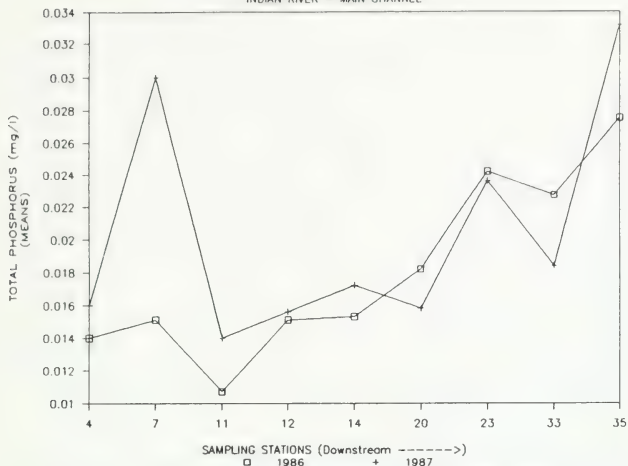


Figure 19: Mean Total Phosphorus Concentrations at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

TOTAL PHOSPHORUS VS SUSPENDED SOLIDS

INDIAN RIVER - MAIN CHANNEL (1987)

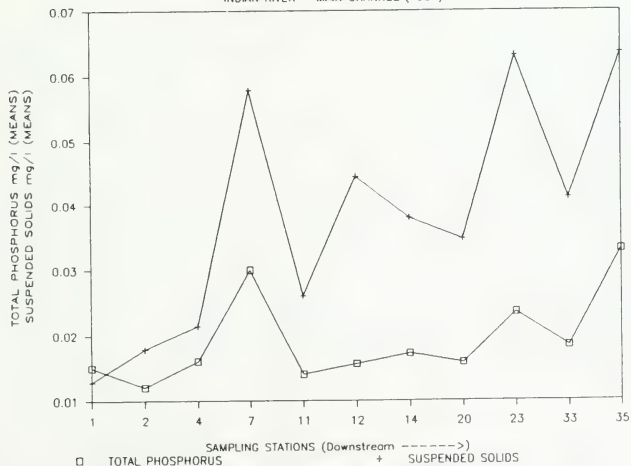


Figure 20: Mean Total Phosphorus Concentrations and Suspended Solids at Indian River Main Channel Stations for the 1987 Sampling Season.

Total phosphorus was significantly correlated with both suspended solids ($p < 0.001$) and turbidity ($p < 0.05$) (Figs. 20, 21). Many sources (Chesters and Schierow, 1985, Jawson et al., 1982; Lowrance et al., 1984, 1985; Maas et al., 1985; Myers et al., 1985) note that plant nutrients (nitrogen and phosphorus) are transported and deposited in association with sediments. The high clay and organic matter portions of soils can hold nutrients on exchange sites. Maas et al., 1985 showed, however, that even though phosphorus loss correlated strongly with erosion rates, erosion control practices do not reduce phosphorus losses as efficiently as they do sediment losses because phosphorus is adsorbed on the finer fractions of sediment that escape most erosion control practices.

It is not surprising that total phosphorus is also strongly correlated with bacteria (fecal coliforms) ($p < 0.01$), (Fig. 22). Total phosphorus concentrations coincide with suspended solids in the water column and previously disturbance of sediments at beach areas was shown to be related to higher bacterial levels. Figures 23 and 24 also show the significant correlation between suspended solids and bacteria ($p < 0.05$), and turbidity and bacteria ($p < 0.001$) for main river stations on the Indian River.

TOTAL PHOSPHORUS VS TURBIDITY

INDIAN RIVER - MAIN CHANNEL (1987)

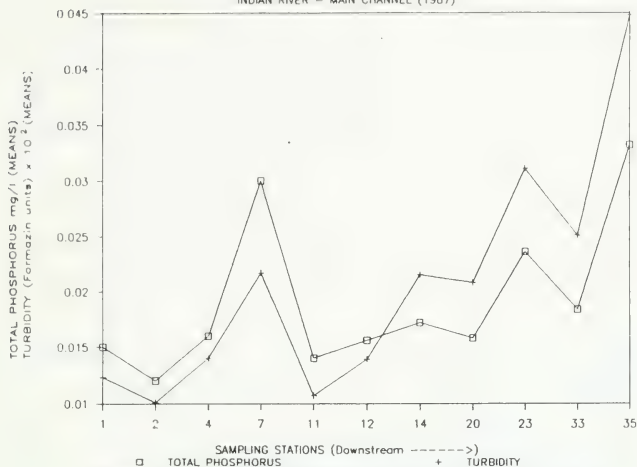


Figure 21: Mean Total Phosphorus Concentrations and Turbidity at Indian River Main Channel Stations for the 1987 Sampling Season.

TOTAL PHOSPHORUS VS BACTERIA

INDIAN RIVER - MAIN CHANNEL (1987)

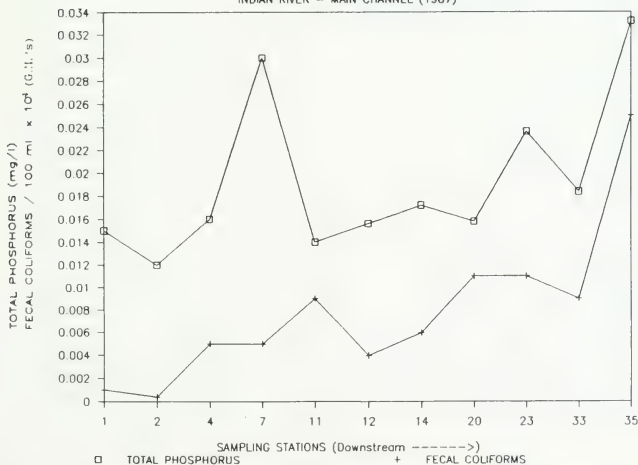


Figure 22: Mean Bacterial and Total Phosphorus Concentrations at Indian River Main Channel Stations for the 1987 Sampling Season.

SUSPENDED SOLIDS VS BACTERIA

INDIAN RIVER - MAIN CHANNEL (1987)

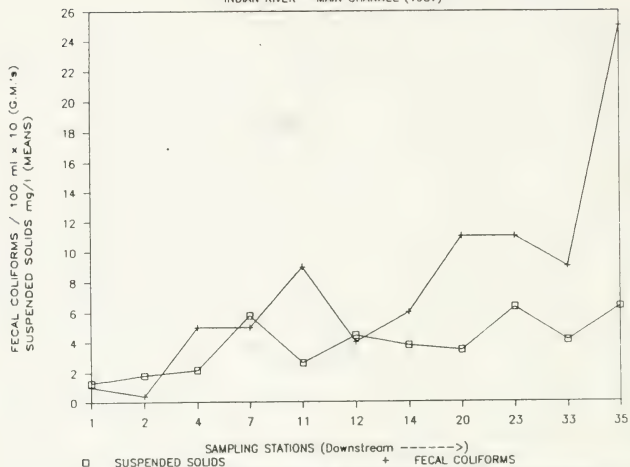


Figure 23: Mean Bacterial Concentrations and Suspended Solids at Indian River Main Channel Stations for the 1987 Sampling Season.

TURBIDITY VS BACTERIA

INDIAN RIVER - MAIN CHANNEL (1987)

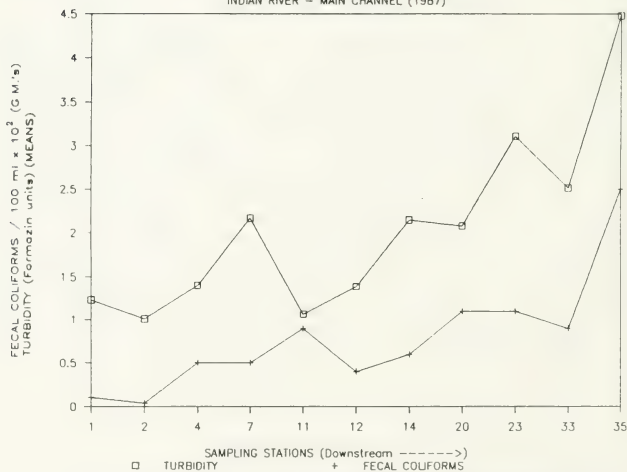


Figure 24: Mean Bacterial Concentrations and Turbidity at Indian River Main Channel Stations for the 1987 Sampling Season.

The total phosphorus discharged by a stream is separated into dissolved phosphorus which remains in the water column and the phosphorus in particulate matter which settles to the bottom under low flow conditions in a lake, pond or widening of the stream. The dissolved phosphorus has a major effect on the biology of waterbodies since it can be utilized by various types of organisms (Porter, 1975).

Dissolved reactive phosphorus constitutes an average of 8% of the total phosphorus concentrations for main river stations sampled in 1987 and an average of 27% for all stations. Station 36 (Keene Village tributary) was the only place where dissolved reactive phosphorus constituted the major portion (75%) of the total phosphorus concentrations for the season. This may indicate an unusual source of phosphorus discharging to this creek. A comparison of dissolved reactive phosphorus concentrations for 1986 and 1987 (Fig. 25) shows similar results for most main river stations with the exception of Stations 23 and 35, which had much higher levels in 1987. Tributaries discharging upstream of both main river stations showed fairly high percentages of dissolved reactive phosphorus. For tributary Stations 21 and 22, monitoring discharges entering upstream of Station 23, those levels were 32% and 45% respectively. Dissolved reactive phosphorus levels were an average of 37%

DISS. REACT. PHOSPHORUS 1986,1987

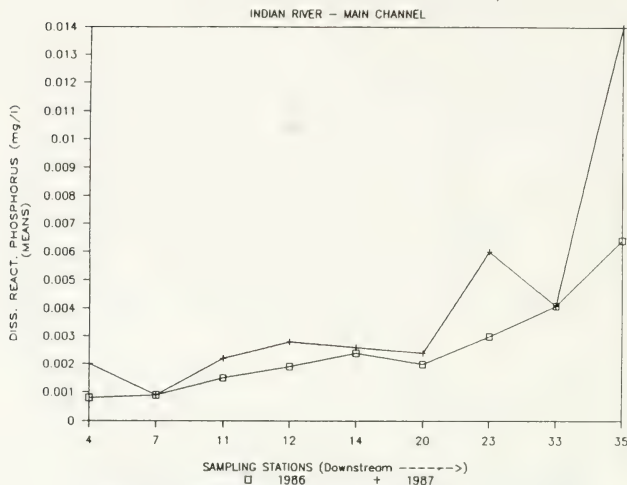


Figure 25: Mean Dissolved Reactive Phosphorus Concentrations at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

MEAN NITROGEN CONCENTRATIONS

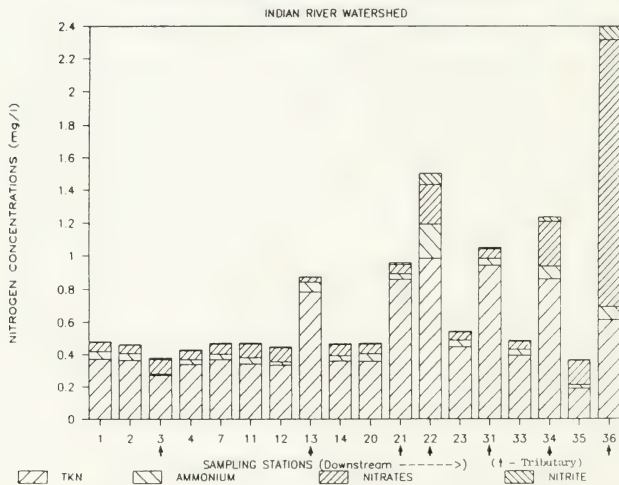


Figure 26: Mean Nitrogen Concentrations at 1637 Sampling Stations in the Indian River Watershed.

of total phosphorus levels for Station 34, a tributary entering the main river upstream of Station 35.

Nitrogen

Mean nitrogen concentrations for all stations sampled in 1987 are illustrated in Figure 26. Nitrogen levels at most main river stations were fairly constant, with a slight increase of total Kjeldahl nitrogen (TKN) at Station 23 and a decrease of TKN and an increase of nitrates at Station 35. Except for the decrease in TKN these fluctuations in main river nitrogen levels seem to correspond with increased tributary nitrogen levels upstream. The high concentration of nitrates at Station 36 indicates one or more sources of urban-related nutrient enrichment such as faulty septic systems and possible fertilizer runoff from farms.

A comparison of total Kjeldahl nitrogen concentrations for 1986 and 1987 (Fig. 27) shows that 1987 levels were on average 15% lower. Nitrate levels, however, were 44% higher in 1987 than in 1986 (Fig. 28).

For the 1987 data nitrates at main river stations on the Indian River were not correlated with bacteria, turbidity or suspended solids. Nitrates were, however, significantly

TOTAL KJELDAHL NITROGEN 1986,1987

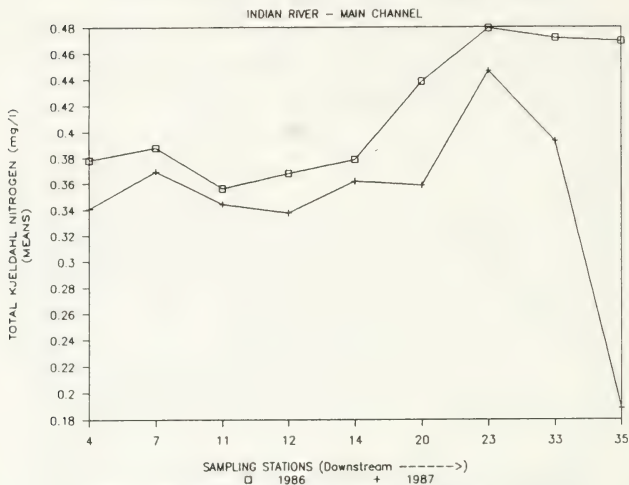


Figure 27: Mean Total Kjeldahl Nitrogen Concentrations at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

NITRATES 1986,1987

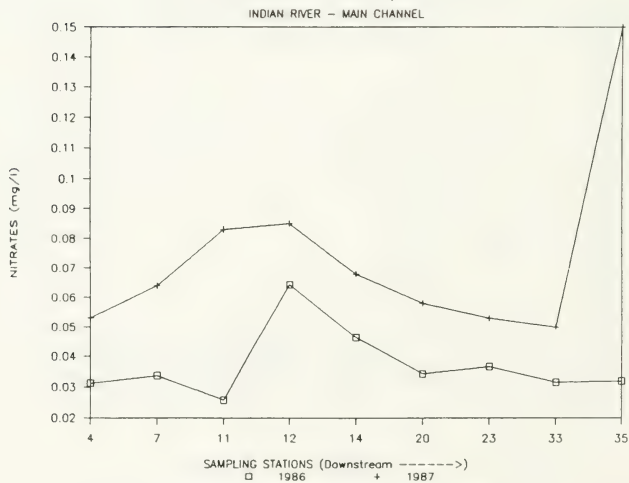


Figure 28: Mean Nitrate Concentrations at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

correlated with total phosphorus ($p < 0.01$), dissolved reactive phosphorus ($p < 0.001$), conductivity ($p < 0.001$) and chloride ($p < 0.001$). Total Kjeldahl nitrogen was significantly correlated with bacteria ($p < 0.05$), suspended solids ($p < 0.001$), turbidity ($p < 0.01$), total phosphorus ($p < 0.001$), and dissolved reactive phosphorus ($p < 0.05$). Ammonium was only significantly correlated with turbidity ($p < 0.05$).

Conductivity

Mean conductivities for all stations sampled in 1987 are shown in Figure 29. Conductivity levels for main river stations increased slightly in a downstream direction. All discharges had substantially higher levels of conductivity than main river stations but these increases had very little effect downstream. Conductivity levels for the main river were very similar for 1986 and 1987 (Fig.30) with 1987 values being just slightly lower.

Chloride

Mean chloride concentrations for all main river stations in 1987 were less than 10 mg/l (Fig.31). The only tributary exhibiting high chloride levels was the Keene Village tributary (Station 36) with a concentration of 95 mg/l.

MEAN CONDUCTIVITY

INDIAN RIVER WATERSHED

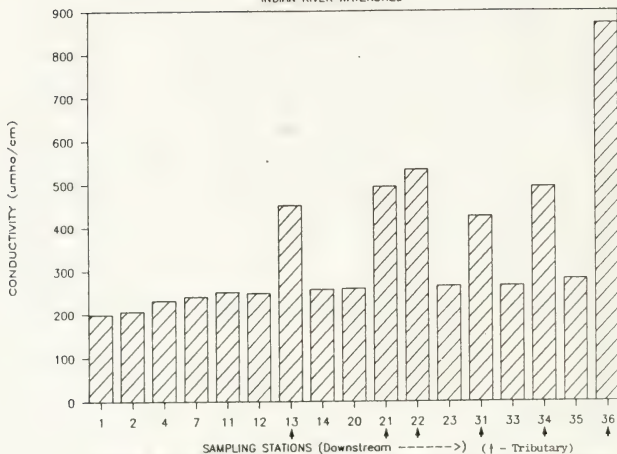


Figure 29: Mean Conductivity at 1987 Sampling Stations in the Indian River Watershed.

CONDUCTIVITY 1986, 1987

INDIAN RIVER - MAIN CHANNEL

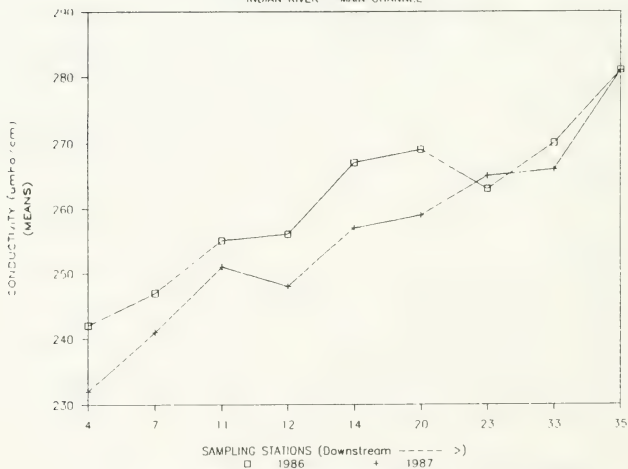


Figure 30: Mean Conductivity at Indian River Main Channel Stations for the 1986 and 1987 Sampling Stations.

MEAN CHLORIDE CONCENTRATIONS

INDIAN RIVER WATERSHED

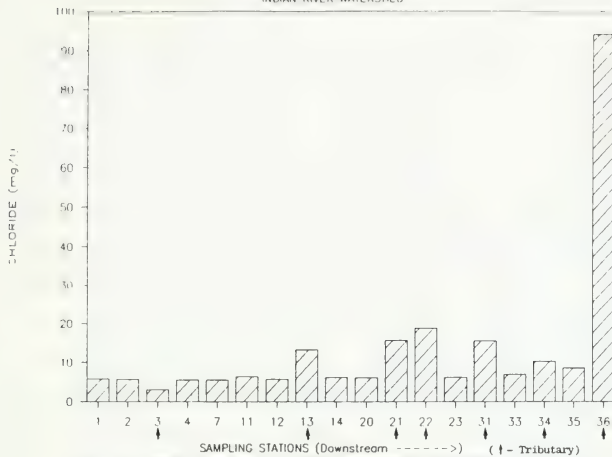


Figure 31: Mean Chloride Concentrations at 1987 Sampling Stations in the Indian River Watershed.

CHLORIDE 1986,1987

INDIAN RIVER - MAIN CHANNEL

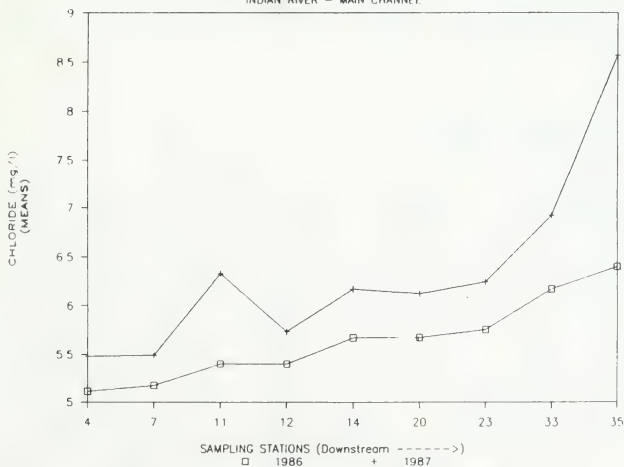


Figure 32: Mean Chloride Concentrations at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

As would be expected chloride was significantly correlated with conductivity for main river stations ($p < 0.001$). A comparison of chloride levels for 1986 and 1987 (Fig. 32) showed that 1987 concentrations were on average 10% higher. It therefore appears that chloride concentrations in the Indian River are higher during periods of lower rainfall.

Turbidity

Turbidity in the main river increased in a downstream direction in 1987 (Fig. 33). Turbidity values for all stations ranged from 1.01 to 5.55 FTU. A comparison of turbidity levels for 1986 and 1987 showed that 1987 values were on average 25% lower (Fig. 34). This corresponds with the much lower precipitation levels for the watershed in 1987.

4.2.2 Water Quantity Monitoring

The Gilchrist Bay Dam regulates the flow of water entering the Indian River from Stony Lake. The level of flow is controlled by the Trent-Severn Waterway Authority in Peterborough. They attempt to maintain flow levels at 1.13-1.7 m³/sec. in the summer and 1.13 m³/sec. in the winter, although the level often drops to 0.42-0.57 m³/sec. by March. During the summer, flows sometimes

MEAN TURBIDITY

INDIAN RIVER WATERSHED

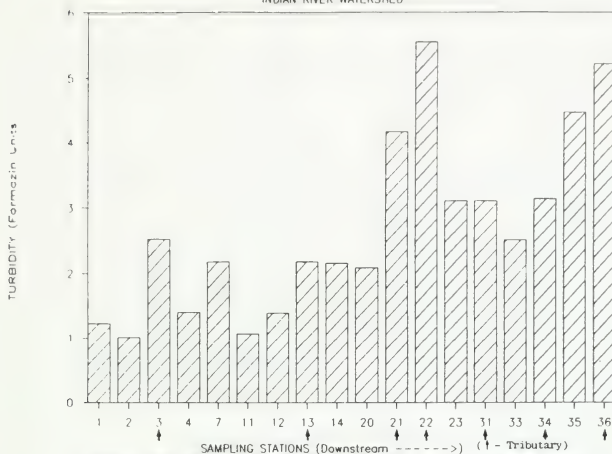


Figure 33: Mean Turbidity at 1987 Sampling Stations in the Indian River Watershed.

TURBIDITY 1986,1987

INDIAN RIVER - MAIN CHANNEL

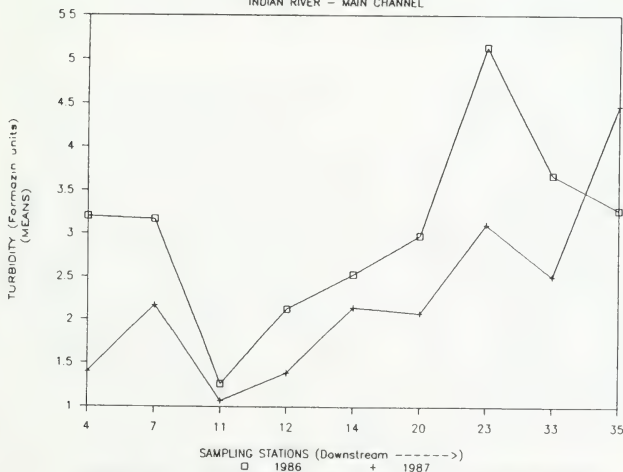


Figure 34 Mean Turbidity at Indian River Main Channel Stations for the 1986 and 1987 Sampling Seasons.

drop below the desired level due to accumulation of debris at the control structure.

Discharge and stage data for the 1987 season are presented in Appendix G. Means of measured discharges for each station are given for the entire field season (March - October), as well as for the bathing season (June - August). Means of measured discharges for the March to October period are illustrated in Figure 35. Discharges for main river stations during the bathing season were on average 3% less than during the entire field season. Tributaries showed much greater differences between the two time periods with discharges for the bathing season being an average of 87% lower. The mean discharge for the main river from March to October was 1.39 m³/sec.

A comparison of the means of measured discharges for 1986 and 1987 (Fig. 36) shows that for main channel stations on the Indian River discharges through the system were much more constant during 1987 than they were for the 1986 season. The greater fluctuations in 1986 may be related to the much higher rainfall levels during that year. Higher precipitation may have been responsible for greater amounts of runoff in some parts of the watershed leading to local increases in discharge.

MEAN DISCHARGE — 1987

INDIAN RIVER WATERSHED

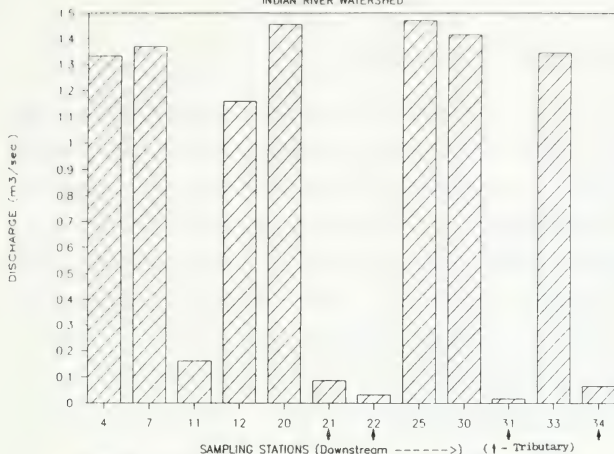


Figure 35: Indian River Watershed Mean Discharges for the 1987 Sampling Season.

DISCHARGE 1986, 1987

INDIAN RIVER — MAIN CHANNEL

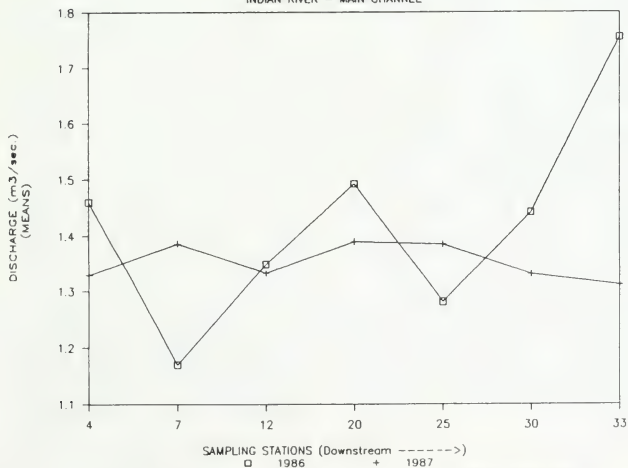


Figure 36: Indian River Main Channel Mean Discharges for the 1986 and 1987 Sampling Seasons.

5.0 LANDOWNER CONTACT PROGRAM

When the Indian River Beaches study was initiated in 1986 it was determined that a landowner contact program would be an integral part of the study in order to assess the impact of land-use practices on the water quality of the Indian River. This segment of the study was separated into two components:

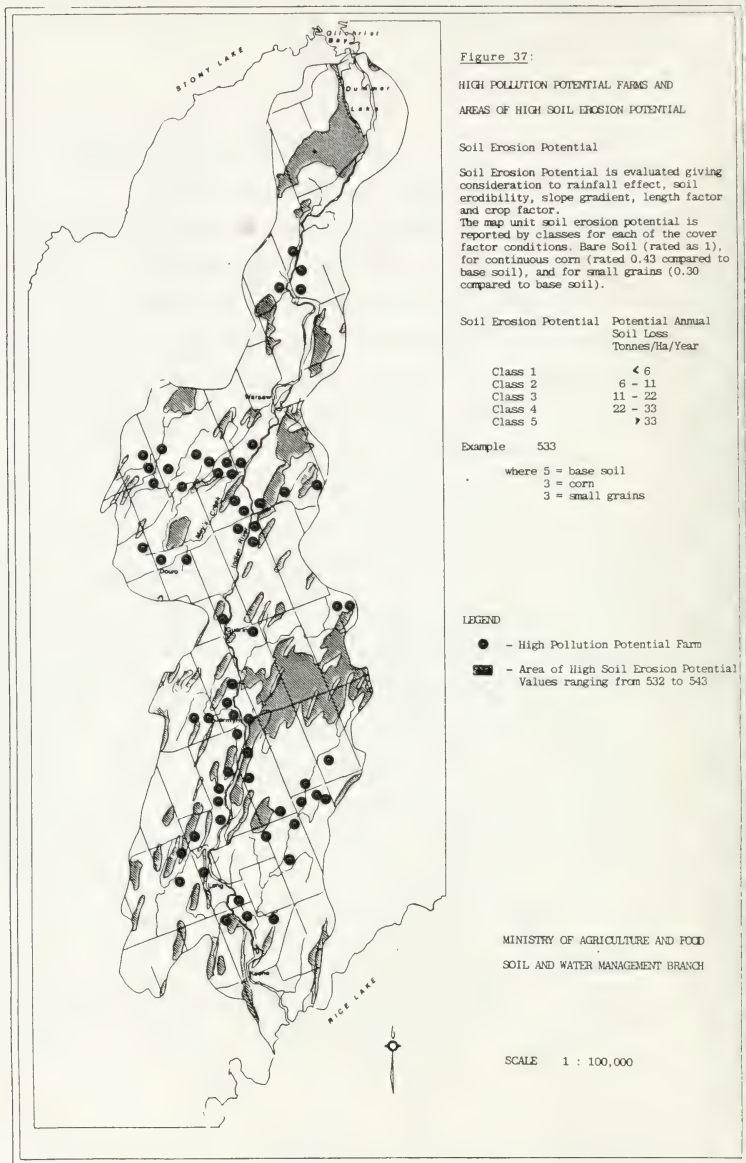
- 1) a large property survey (those landowners possessing more than 10 acres of land) and
- 2) a small property survey (those landowners possessing 10 acres of land or less).

5.1 Large Property Survey

During the early spring of 1986 township offices were visited and a list was compiled of all large properties located within the Indian River Watershed. Information on individual landholdings such as mailing address, lot, concession, township and property size were recorded. Each landowner was assigned a corresponding identification number and these were plotted on a base map. At this time letters were mailed out to those landowners possessing property adjacent to the Indian River or any of its tributaries, outlining the purpose of the study, the agencies involved and requesting the co-operation of individuals when they were contacted over the course of the summer. During the

1986 field season 133 landowners were visited by pre-arranged appointment, and presented with a twenty minute questionnaire (Appendix H) concerning their land-use practices. At this time the study team had an opportunity to visually assess the property and prepare a site map illustrating the locations of the house, barn, feedlot and manure storage area in respect to the watercourse. Direct livestock access to the watercourse was also noted.

Utilizing data received from the questionnaire, combined with visual assessments and information taken from soil erosion potential maps obtained from O.M.A.F., the pollution potential of each landowner was determined. Ranking of pollution potential into categories of low, medium and high was undertaken using the criteria described in Appendix I. Of the 133 landowners interviewed 48 (36%) had a low potential to pollute, 25 (19%) ranked as medium and 60 (45%) of the landowners were ranked as high potential polluters. High pollution potential farms and areas of high soil erosion potential are shown in Fig. 37. Areas corresponding to low, medium and high pollution potential were plotted on a base map and an assessment was done to estimate the cumulative number of high pollution potential farms located upstream of main river stations (Fig. 38). This graph illustrates the intensive agricultural land-use in the



HIGH POLLUTION POTENTIAL – UPSTREAM

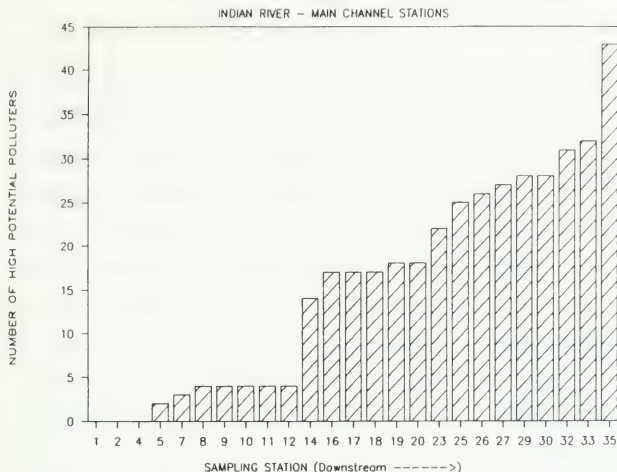


Figure 38: Number of High Pollution Potential Farms Located Upstream of Main Channel Stations - Indian River, 1987.

HIGH POLLUTION POTENTIAL VS BACTERIA

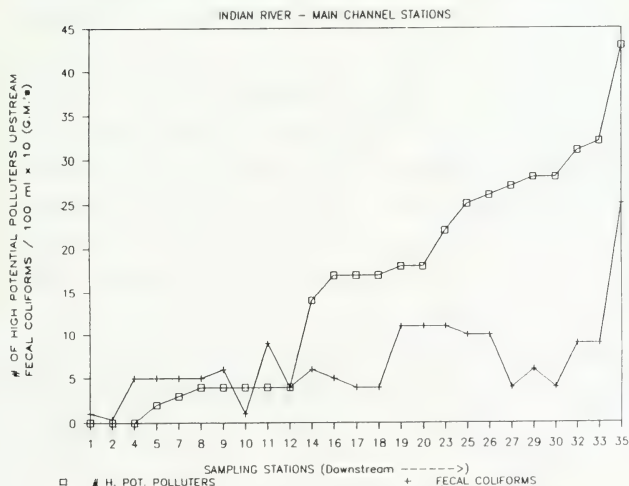


Figure 39: Number of High Pollution Potential Farms Upstream of Main Channel Stations and Corresponding Bacterial Concentrations at Main Channel Stations - Indian River, 1987.

Indian River watershed south of the Village of Warsaw (Station 12). The increase in number of high pollution potential farms between Warsaw and Station 14 are largely the result of the May's Creek tributary watershed monitored at Station 13, as well as farms located along the main river in this area. Although there is an increase of only one high pollution potential farm between Stations 18 and 19, a sharp rise in bacterial concentration is noted at this point (Fig. 39). This may be a result of the farm located at Station 19, which allows heavy direct cattle access to the main river and the proximity of a feedlot to the watercourse. Continuing downstream, bacterial concentrations remain high until Station 27, corresponding to a rise on the graph identifying a consistent increase in number of farms with a high potential to pollute. Between Stations 33 and 35 a distinct increase occurs both in bacterial concentrations and number of high potential polluters. The tributary monitored at Station 34 contributes substantially to both these figures.

The results of the landowner questionnaire (Appendix J) indicate that beef farming is the primary agricultural operation undertaken in the Indian River watershed. Of the 133 landowners interviewed 77 raised beef cattle compared with 18 dairy operations, 2 poultry farms and 4 swine

operations. Eighty percent of the farmers who raise livestock also grow their own crops. Of the 96 farms supporting a cattle operation 70 (73%) have direct livestock access to the watercourse; 56 of these are along the main river. Twenty-five farm operations (26%) had manure storage areas located less than 150 m from the watercourse. Out of 18 dairy operators interviewed 8 stated that they had no system of dealing with milkhouse waste and 7 others chose not to answer the question. Only 18 landowners had tile drained fields and 14 of these drained to a natural watercourse. Ten people were considering future tile installation. Overall, erosion was not considered to be a problem in the Indian River watershed. Only two landowners expressed a concern in this area.

The results of the large property questionnaire were recorded on computer disc and sent to O.M.A.F. in Toronto along with the landowner and pollution potential maps. A base map of the Indian River watershed was digitized and then several overlays depicting various aspects of land-use were prepared.

It became evident through the interviewing process that information and education are required to inform landowners of the environmental impacts of agricultural pollution. In

the majority of cases landowners willingly responded to the questionnaires and did not consider traditional farming practices to be a contributor to a pollution problem. The Indian River watershed is not an affluent agricultural area, and as a result expense may discourage acceptance of remedial action plans.

5.2 Small Property Survey

During the winter of 1987 township offices were visited to compile a list of small properties adjacent to a watercourse in the Indian River watershed. Each landowner was given an identification number and these were plotted on several small scale maps obtained from the township offices. From mid-May until mid-September of 1987, 259 landowners were visited by pre-arranged appointment and presented with a brief questionnaire (Appendix K) regarding water supply and sewage disposal systems. The study team prepared site maps illustrating the location and size of the house, septic system and well, with respect to the watercourse.

The results of this questionnaire (Appendix L) indicate that 96% of residences are occupied by the owner rather than rented, and 42% of these are occupied year round as permanent dwellings; an additional 31% are occupied on a

seasonal basis. Only 27% of the residential properties surrounding Dummer Lake and the Indian River are occupied on a weekend or occasional basis. A large percentage of the residences (57%) are three bedroom homes. Fifty-seven percent of the landowners had their water tested within the last five years and only 3.5% found contaminants in their water supply. Water usage by landowners was almost exclusively domestic. The majority of landowners (84%) had septic systems and 76% of these were less than 20 years old, however, very few landowners had their septic tank pumped on a regular basis. Based on interviews and visual assessments 63 (24%) of this group were considered to have potentially inadequate waste disposal systems. Forty-four (70%) of these residences were located on Dummer Lake, 13 (21%) were in the Village of Warsaw, and 6 (9%) were from Otonabee Township. These names and locations were forwarded to the Peterborough County-City Health Unit for further investigation. Septic systems on large properties were not assessed in detail, therefore statistics are not available for these.

6.0 CONCLUSIONS

This section presents the conclusions from the two year Indian River Beaches Study in terms of the water quality field sampling program and the landowner contact program. Section 7.0 details a Remedial Action Plan for correction of problem areas identified within the Indian River watershed during the study period.

The results from this study indicate that beach closures along the Indian River are directly related to agricultural land-use practices, especially unrestricted cattle access to waterways. Beach closures at the Warsaw Caves Conservation Area, Douro Municipal Park and the Hope Mill Conservation Area were also shown to be correlated with high precipitation levels, which result in runoff of bacteria. For the entire watershed wet weather bacterial concentrations were an average of 73% greater than dry weather levels. At the Lang Mill Conservation Area beach, closures appeared to be affected primarily by immediate sources of bacterial contamination and were not related to rainfall events.

Two sections of the Indian River had seasonal fecal coliform geometric means greater than 100/100 ml. These areas included a 6.5 km stretch of the river from Guerin to

approximately 3 km south of Highway 7, and a 4.5 km length of river from Lang Mill beach to the Keene bridge. High bacterial levels in the upstream section are primarily the result of farming practices along both the main river and tributaries entering in this region. Out of the 60 high priority farms identified during the study, 16 (27%) are located within this area. Eleven of these farms are situated directly along the main river. Bacterial problems in the downstream section of the river appear to be a combination of farming practices and urban-related causes. Fourteen (23%) high priority farms were identified within this portion of the watershed, although only 4 are located on the main river. The remaining 10 farms are distributed along Cameron Creek and are responsible for very high bacterial levels within this tributary, which discharges to the main river about 1.5 km north of the Village of Keene. The problems along this creek consist primarily of unrestricted cattle access to the stream and runoff from feedlots and manure storage areas. Mass balance equations showed, however, that this tributary should only be having a slight effect on increased bacterial levels in the main river. Urban bacterial inputs from the Village of Keene, likely as a result of faulty sewage disposal systems, appear to be contributing to the high bacterial counts at the Keene bridge.

It is interesting to note that although the Hope Mill beach is directly downstream from the most northerly problem area it experiences the lowest number of beach closures. This is partly due to the fact there are no major agricultural problems for at least 1 km upstream of the beach and may also be partially the result of sediment types at the beach. The bacterial sediment assessment showed that at the Hope Mill beach fecal coliform counts were not much higher in disturbed versus undisturbed samples. This is in contrast to the Douro Park and Lang Mill beaches where agitation of river bottom sediments produced higher bacterial levels a greater percentage of the time. This may explain in part why the Douro Park beach, which is located within a stretch of the river which does not experience high bacterial counts, would be closed a fairly high percentage of the swimming season compared with the other beach areas.

Bacterial counts and subsequent beach closures tend to vary considerably between years at both the Warsaw Caves and Lang Mill beaches. At both areas there have been very localized sources of pollution which have changed from year to year. Until 1987 the Warsaw Caves beach was being impacted by runoff from a manure storage area and a pasture situated upstream from the beach. These appeared to have less effect on bacterial counts at the swimming area during 1987 because

of lower precipitation levels. At the Lang Mill beach, closures were more frequent in 1987 compared with 1986. Increased cattle access just upstream from the swimming area in 1987, as well as the presence of a population of ducks and geese at the beach during the bathing season which were not present in 1986, may both have contributed to this problem.

The most severe water quality problem encountered in this study was in the Keene Village Tributary. During both years of sampling this creek had very high bacterial and chemical levels. The results were reported to the Peterborough County-City Health Unit and their subsequent investigation led to a clean up/or replacement of septic systems and laundry wastes at local businesses and private residences within the village.

Rain event sampling during 1987 showed that fecal coliform levels in the main river tended to peak approximately 24 hours after the rainfall began. This result is for rainfall events when greater than 10 mm of rain fell within a 24 hour period.

Sampling for the bacterial indicator Pseudomonas aeruginosa showed that levels of this bacterium were usually less than

10/100 ml except in the Keene Village Tributary where counts ranged from less than 10/100 ml to 650/100 ml with a geometric mean value of 10/100 ml for the 1987 season. Analysis for fecal coliforms and Escherichia coli bacteria showed that E. coli ranged from 7% to 100% of the fecal coliforms with a mean of 70% for the watershed.

Levels of nutrients and suspended solids in the main channel of the Indian River appear to be quite acceptable. Total phosphorus levels only exceeded the M.O.E. guideline of 0.03 mg/l at one main river station (at the Keene bridge). Results showed that phosphorus levels were correlated with both fecal coliform levels and suspended solid concentrations for the main river.

Results from the landowner contact program showed that 45% of landowners with large properties interviewed ranked as high potential polluters to the waterway. Land-use practices responsible for these high rankings included unrestricted cattle access to the main river or tributary, runoff from feedlots and manure storage areas, manure handling practices and disposal of milkhouse wastes. Beef farming is the primary agricultural operation within the Indian River watershed. Seventy-three percent of these operations have direct cattle access to a watercourse and

26% had manure storage areas less than 150 m from a waterway. From the interview process it became evident that information and education programs are required to inform landowners about the environmental impacts of agricultural pollution. Most landowners responded willingly to the questionnaires and did not consider traditional farming practices to be a problem.

Results from interviews of landowners with small properties showed that 24% of those households interviewed had potentially inadequate waste disposal systems. Seventy percent of these cases were found on Dummer Lake, 21% in the Village of Warsaw and 9% in Otonabee Township. It is interesting to note that even though the highest percentage of problems occurred on Dummer Lake, based on results of sampling at the outflow, the water quality in the lake is good.

7.0 REMEDIAL ACTION PLAN

The two year water quality study on the Indian River identified some problem areas along the river which should be considered for remedial work. This remedial work would primarily consist of cattle fencing and the provision of an alternate water supply or restricted access to the river.

The Ontario Ministry of Agriculture and Food currently has a program to provide capital grants for on-farm erosion control projects including fencing, and manure storage facilities. The program is called The Ontario Soil Conservation and Environmental Protection Assistance Program (O.S.C.E.P.A.P.). The province will pay, in the form of a grant, 66.66 percent of the eligible cost of work on an approved soil erosion control project, engineering fees and supervision costs, where required, up to a maximum of \$10,000.00 per farm operation. On a manure storage project the province will pay 40 percent of the eligible cost of work up to \$7,500.00 per farm operation. The farm operation must, however, show an annual income of \$12,000.00 to be eligible to receive an O.S.C.E.P.A.P. grant.

The Otonabee Region Conservation Authority should consider contributing funds and/or manpower to accomplish some of the

remedial work along the Indian River. In addition, the Ontario Ministry of the Environment should be requested to contribute toward the required remedial action work identified in the rural beaches studies.

There are several ways to approach a remedial action work plan. One way is to concentrate on the upstream areas affecting each beach. Another alternative is to give priority to sources of high pollution potential. A third approach is to choose one or two stretches of the river with water quality problems and concentrate on those areas first. For the Indian River we feel that the best method is to deal with each beach separately, in terms of remedial work, since the original aim of the study was to identify and correct the problems affecting the beaches. This remedial action plan is targeted towards agricultural problems. Problems identified in the small property survey are being handled by the Peterborough County-City Health Unit.

7.1 Calculation of Beach Priorization

To assess the necessary remedial work required to clean up each beach and to prioritize the order of work, the distances of main river high pollution potential farms upstream of each beach were calculated. Then using the water velocities

for the points on the main river where these farms were situated, the time of travel was estimated from each farm to the beach downstream. The wet weather fecal coliform geometric means for 1987 at each of these points were noted and expected bacterial die-off rates were calculated for the distance from each farm to the beach. A bacterial die-off rate of 58.5% for a 24 hour period was used. This was obtained from a bacterial die-off study undertaken in Pefferlaw Creek by the Lake Simcoe Region Conservation Authority. We made the underlying assumption that bacterial die-off is constant over the 24 hour period and then calculated the rate according to the estimated time of travel from each farm. The calculations showed that it was not necessary to go any further than the next beach upstream to find the farms which appear to be affecting the water quality at each beach. Due to the low discharge of tributaries into the main river, it has also been determined to be unnecessary to concentrate on high pollution potential farms on the tributaries in order to clean up the beaches.

7.2 Cost/Benefit Analysis

During the years 1985-1987 the beaches along the Indian River have been placarded on a fairly consistent basis by the Peterborough County-City Health Unit (Table 3). From the user statistics available at the Otonabee Region

Conservation Authority for the Warsaw Caves and Hope Mill Conservation Areas, this has substantially affected use of these areas and, hence, revenue.

The statistics indicate that day-use, and therefore day-use revenue, have decreased by 28% at Warsaw Caves since 1984 (Table 6). At Hope Mill Beach during the same time period the decrease in day-use has been 66% (Table 7). Beach closures do not appear to have caused such a striking reduction in campground use, however, a decline is noted.

Table 6: Warsaw Caves Conservation Area User Statistics, 1984-1987

Year	User Days	Day Use Revenue	Camper Nights	Camping Revenue
1984	8990	\$6,422.50	2306	\$3,730.50
1985	10810	\$7,722.50	2706	\$3,243.00
1986	7276	\$5,197.50	2085	\$3,137.00
1987	6483	\$4,630.00	1824	\$3,223.00

Table 7: Hope Mill Conservation Area User Statistics, 1984-1987

Year	User Days	Day Use Revenue	Camper Nights	Camping Revenue
1984	2821	\$2,015.00	4049	\$6,457.00
1985	2177	\$1,555.00	3200	\$5,971.50
1986	1565	\$1,117.50	3269	\$5,050.00
1987	946	\$ 675.00	2917	\$5,956.50

Warsaw Caves Conservation Area is less affected than the Hope Mill Conservation Area as a result of beach closures because Warsaw Caves is not as dependent upon swimming to draw campers and day users to the area. Unfortunately there are no user statistics available for the Douro Park or Lang Mill Beaches. Reopening of the beaches has the potential to substantially increase use and revenue at day-use and camping facilities along the Indian River.

Intangible benefits include the reduction of bacteria in the watercourse, reduced potential for illness and the pleasure of increased recreational opportunities to both the local population and tourists. These benefits, while being important, are difficult to quantify and are therefore not accounted for in monetary terms in the cost/benefit analysis. On the pages that follow the costs and benefits of cleaning up each beach area are presented. Costs have been estimated in a conservative fashion, and further on in the report alternatives will be suggested. There has been no cost estimated for items regarding movement of a manure storage area and relocation of a local waterfowl population. It is unknown what these costs would be, if any, however, it is necessary that these problems be identified.

Costs:

1. Warsaw Caves Beach - Three high priority farms contributing to water quality degradation.

750 m fencing	\$ 4,920.00
1 controlled access point	\$ 1,000.00
1 manure storage area moved	--

Total Cost	\$ 5,920.00

2. Douro Park Beach - Five high priority farms contributing to water quality degradation.

3300 m fencing	\$ 21,648.00
7 controlled access points	\$ 7,000.00

Total Cost	\$ 28,648.00

3. Hope Mill Beach - Six high priority farms contributing to water quality degradation.

4350 m fencing	\$ 28,536.00
10 controlled access points	\$ 10,000.00

Total Cost	\$ 38,000.00

4. Lang Mill Beach - One high priority farm contributing to water quality degradation.

750 m fencing	\$ 4,920.00
2 controlled access points	\$ 2,000.00
Relocate waterfowl population	--

Total Cost	\$ 6,920.00

Benefits:

1. Warsaw Caves Conservation Area - based on maximum utilization of group campgrounds in 1988 and 1984 day-use statistics.

3 group campsites x \$5/night x 86 nights	\$ 1,290.00
Projected day-use revenue	\$ 6,422.00
Canoe rentals 2 x \$10/day x 86 days	\$ 1,720.00

Potential Annual Revenue:	\$ 9,432.00
1987 Revenue:	\$ 6,335.00

Potential Annual Benefit:	\$ 3,097.00

2. Douro Park Beach - Benefits intangible

3. Hope Mill Conservation Area - based on maximum utilization of campgrounds in 1988 and 1984 day-use statistics.

1 group campsite x \$5/night x 86 nights	\$ 430.00
45 campsites x \$6/night x 86 nights	*\$23,220.00
20 campsites x \$7.50/night x 86 nights	*\$12,900.00
Firewood - 1 bundle (\$1.50)/campsite/night	\$ 8,514.00
Canoe Rentals 2 x \$10/day x 86 days	\$ 1,720.00
Projected day-use revenue	\$ 2,015.00

Potential Annual Revenue:	*\$48,799.00
1987 Revenue:	\$ 7,681.00

Potential Annual Benefit:	*\$40,817.50

*The estimate of potential annual benefits is based upon maximum campground utilization. It is probable that this increase will not be realized within the first year. However, even if we assume only a fifty percent utilization, the initial cost of remedial work would be

returned fivefold over a ten year period.

4. Lang Mill Conservation Area - Benefits intangible

7.3 Farm Visits

As a component of the remedial action plan, farm visitation was again undertaken in an effort to assess the level of interest in the farming community with respect to having remedial work done on individual properties. A number of farmers were visited and the results of the study were discussed with them, as well as possible corrective measures which could be used to improve the quality of water at the bathing beaches.

The response from the farming community was, for the most part, negative in that they do not agree that the Indian River has a water quality problem, or that it has changed over the past 150 years. There have been no known cases of sickness due to swimming in the Indian River. As a result, there is a reluctance to participate in a remedial action plan. People mentioned problems they had encountered in the past when considering stream bank fencing. It is difficult, and in some cases impossible, to put postholes in the bedrock which is so predominant and close to the surface throughout much of the Indian River watershed. In some

cases there is also a need to place the fence as much as 100 m back from the river to avoid ice damage in the spring. If such a fence were built it would mean loss of access to valuable pastureland.

Farms within the Indian River watershed are generally small and generate only minimal income. Additionally, the majority of farmers approached are elderly and are considering retirement within the next few years. Unless full funding is offered for remedial work, few of the individuals interviewed will be interested in participating. Even with total financial assistance most of those affected do not wish to participate.

There is one individual with a very large operation located both on the river and a tributary, who has expressed an interest in becoming involved in a demonstration project. We are presently working with the O.M.A.F. office in Lindsay to develop a plan for remedial work on this farm.

7.4 Strategy

Beaches have been prioritized for remedial work based on benefit and use. Hope Mill has top priority for a number of reasons. It has the best bathing beach available on the Indian River by virtue of size and capacity for the greatest

number of bathers, as well as a well maintained picnic area and shelter, adequate parking and an associated campground and historic site. Additionally, the Hope Mill Beach has the potential to attract revenue both to the Conservation Authority and local merchants.

The beach at Warsaw Caves Conservation Area would be considered second priority. The beach here is smaller than the one at Hope, but still has the potential to attract revenue. It has been stated previously, however, that revenue at Warsaw is less dependent upon the beach than what it is at Hope Mill Conservation Area.

Douro Park has been given third priority of the four beach areas, due to its large use. Many soccer and baseball tournaments occur here throughout the summer. As well, many people visit Douro Park on a regular basis. It is the only beach in the immediate vicinity, and as a result is crowded on the weekends.

Lang Mill Beach has been assigned fourth priority. Beach use here is auxillary to the main purpose of the Lang Century Village.

7.4.1 Recommendations

Funding for remedial work is a major problem in the Indian River watershed. The O.S.C.E.P.A.P. program provided through O.M.A.F. covers a percentage of the cost of some remedial measure. Unfortunately, the funding provided under this program is still not enough to make implementation financially feasible. In many cases it is likely that individuals do not have the necessary annual farm income (\$12,000.00) to make them eligible for grants under the O.S.C.E.P.A.P. program. For this reason additional or potentially full funding must come from other sources if a successful remedial action plan is to be carried out. The Conservation Authority has expressed an interest in supporting the remedial work through funds and/or manpower. It is therefore recommended that the Otonabee Region Conservation Authority budget appropriate funds to supplement other sources of support. We suggest that the Ministry of the Environment also become involved financially in order to make the incentive appealing to those who presently are not interested.

If further funding was made available to landowners, work beyond that which has been discussed in the cost/benefit analysis might be possible, including some options which may be more acceptable to those who are not presently interested.

One prospect is temporary fencing. This would alleviate the problems associated with ice damage and digging postholes in bedrock. It would allow seasonal fencing to be erected closer to the watercourse, permitting fuller utilization of pastureland and also grant the additional freedom of portability if an owner desired to change the boundaries of a pasture. Improved manure storage areas could also be implemented in a few situations. Other possibilities which have been discussed include solar powered water supplies and livestock crossovers on the watercourse.

We suggest that the Steering Committee be kept in place for further technical advice and assistance in implementing the remedial action plan. We also recommend that a smaller scale water quality monitoring program take place to assess the benefits of any remedial work which is undertaken. This monitoring program would best be done following the format which has occurred over the last two years, for the purpose of consistency. We propose that funding continue through the Rural Beaches Program of the Ministry of the Environment in order to see the project through to completion. Costs will be substantially lower than in 1986 and 1987 due to fewer sampling stations and less manpower required. However, the Conservation Authority feels strongly that the beaches and any areas where remedial work occurs should be

monitored to note changes in water quality after the work has been done.

The Indian River Beaches have been closed to bathers an increasing amount throughout the last three years. The bacterial levels causing the beach closures are frequently just barely over the 100 FC/100 ml objective set by the Ministry of Health. We would suggest that the Indian River watershed could soon have four bathing beaches open for swimming at reasonable cost, over a short period of time. There is a possibility of this cost being recouped within the first year. The potential for a successful clean up of the beaches in this watershed makes it highly desirable that work towards this end be continued.

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9.0 APPENDICES

Appendix A: Bacterial Concentrations (FC/100ml) for Indian River Sampling Stations, March - October, 1987.

STATION	1		2		3		4		5		6		7		8		9		10		11		12	
	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL	FC	PL
WATER																								
MARCH 13	70	0	110	0	110	0	110	0	110	0	110	0	110	0	110	0	110	0	110	0	110	0	110	0
MARCH 14	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
APRIL 1	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
APRIL 4	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
APRIL 7	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
MAY 5	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
MAY 11	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
MAY 18	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
MAY 25	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
MAY 31	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JUNE 7	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JUNE 14	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JUNE 21	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JUNE 28	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JULY 5	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JULY 12	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JULY 19	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
JULY 26	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
AUGUST 2	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
AUGUST 9	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
AUGUST 16	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
AUGUST 23	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
AUGUST 30	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
SEPTEMBER 6	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
SEPTEMBER 13	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
SEPTEMBER 20	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
SEPTEMBER 27	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
OCTOBER 4	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
SEDIMENT																								
MARCH 13	10	7	170	60	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
MARCH 14	10	5	70	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Appendix A: Continued

Values recorded as " " were dealt with as the value given when calculating geometric means. This occurred infrequently and therefore did not significantly affect the results. Values recorded as " " were dealt with by correcting to the dilution used in the lab analysis.

DATE	ST	FC	Ph.	FC	Ph.	ST	FC	Ph.	FC	Ph.	ST	FC	Ph.	FC	Ph.
MARCH 13															
MARCH 14															
APRIL 1															
APRIL 11															
APRIL 12															
APRIL 13															
APRIL 14															
APRIL 15															
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Appendix B:

PHYSICAL CHARACTERISTICS OF THE INDIAN RIVER BEACHES

Beach	Beach Length (m)	Dry Beach Width (m)	Wet Beach Width (m)	Sediment Composition	Aquatic Vegetation Cover
Warsaw Caves	30.5	8	25	limestone bedrock, silt,sand, gravel	0%
Douro Park	69	4.5	24	limestone bedrock, silt,sand, gravel	10%
Hope Mill	56	14	30.5	sand,gravel, muck	1%
Lang Mill	44	6	14	silt,sand, muck	80%

Appendix C: Fecal Coliform Concentrations and Escherichia coli Concentrations From the Same Samples Taken at Indian River Sampling Stations on October 5, 1987.

STATION	FC/100ml	Ec/100ml	E.coli	STATION	FC/100ml	Ec/100ml	E.coli
1	40	20	50	19	290	290	100
2	L10 (5)	L10 (5)	100	20	260	260	100
4	60	30	50	21	350	350	100
5	70	50	71	22	1000	1000	100
7	80	50	63	23	200	200	100
8	90	50	56	25	120	90	75
9	100	80	80	26	290	60	21
10	30	10	33	27	200	90	45
11	450	30	7	29	50	10	20
12	40	40	100	30	50	L10 (5)	10
13	30	30	100	32	60	60	100
14	40	40	100	33	30	30	100
16	60	40	67	34	1000	1000	100
17	30	30	100	35	210	130	62
18	60	20	33				

E.coli counts were an average of 70% of Fecal coliform levels for the Indian River on October 5, 1987.

Appendix D: Mass Balance Equations

(discharge upstream x concentration upstream) + (discharge of the tributary inflow x concentration of the tributary inflow)

= (discharge upstream + discharge of the tributary inflow) x (concentration downstream)

<u>Upstream Station</u>		<u>Tributary Station</u>		<u>Predicted Downstream</u>		<u>Actual Downstream</u>	
<u>Station</u>	<u>FC/100ml</u>	<u>Station</u>	<u>FC/100ml</u>	<u>Concentration</u>	<u>FC/100ml</u>	<u>Concentration</u>	<u>FC/100ml</u>
20	110	22	600	120	23	110	
30	40	31	330	40	32	90	
33	100	34	490	120	35	250	

Appendix E: Chemical Analyses for Indian River Sampling Locations, March - October, 1987.

STATION 2 1987

DATE	CONDUCTIVITY	pH	CHLORIDE RESIDUE	TURBIDITY	PHOSPHORUS	PHOSPHATES	NITROGEN TOT.	AMMONIUM TOTAL	NITRATES TOT.	NITRITE
			PARTICULATE		UNF. TOTAL	FRAC. REACT.	KJELD UNF. R.	FRAC. REACT.	FRAC. REACT.	FRAC. REACT.
	umho/cm @ 25C		ng/l	Formazin U.	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l
MAR. 22	199	8.12	5.4	0.6	1.46	0.007	0.0005	0.41	0.024	0.195
APR. 7	167	7.93	4.3	0.6	1.11	0.011	0.005	0.26	0.02	0.12
MAY 11										
MAY 25	207	8.12	5.65	1.6	1.58	0.013	0.0065	0.39	0.074	0.055
JUNE 9	218	8.22	5.6	1.7	1.22	0.014	0.0025	0.35	0.038	0.02
JUNE 22	205	8.12	5.9	0.9	0.72	0.011	0.0025	0.39	0.09	0.025
JULY 6	285	8.21	6.1	4.3	1.2	0.004	0.0005	0.33	0.046	0.02
JULY 20	205	8.24	6.15	1	2.7	ICR	0.003	0.31	0.042	0.02
AUG. 17	196	8.46	6.3	0.1	1.67	0.032	0.001	0.45	0.06	0.07
SEPT. 8	193	8.41	6.15	1.2	0.58	0.017	0.001	0.41	0.046	0.02
SEPT. 21	199	8.38	6.2	1.5	0.9	0.01	0.002	0.38	0.036	0.025
OCT. 5	199	8.26	6.1	0.6	0.35	0.041	0.0135	0.42	0.028	0.04
MEAN	199.36	8.2	5.8	1.28	1.23	0.015	0.0035	0.373	0.046	0.055

STATION 2 1987

DATE	CONDUCTIVITY	pH	CHLORIDE RESIDUE	TURBIDITY	PHOSPHORUS	PHOSPHATES	NITROGEN TOT.	AMMONIUM TOTAL	NITRATES TOT.	NITRITE
	umho/cm @ 25C		PARTICULATE		UNF. TOTAL	FRAC. REACT.	KJELD UNF. R.	FRAC. REACT.	FRAC. REACT.	FRAC. REACT.
			ng/l	Formazin U.	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l
MAR. 23	197	8.14	5.45	0.9	0.68	0.007	0.0005	0.4	0.018	0.19
APR. 7	192	8.04	4.65	0.95	1.25	0.008	0.0005	0.22	0.008	0.115
MAY 11										
MAY 25	320	8.31	5.1	2	1.58	0.008	0.0025	0.34	0.034	0.025
JUNE 9	210	8.09	6.2	2.7	1.66	0.016	0.003	0.47	0.044	0.02
JUNE 22	217	8.3	5.5	0.7	0.38	0.009	0.0005	0.3	0.034	0.02
JULY 6	218	8.37	5.2	4.3	0.33	0.008	0.0005	0.34	0.06	0.02
JULY 20	214	8.62	5.8	3.5	1	ICR	0.001	0.38	0.028	0.02
AUG. 17	206	8.51	6.65	0.9	1.65	0.033	0.0005	0.38	0.056	0.07
SEPT. 8	198	8.36	5.95	1.7	0.9	0.023	0.0005	0.43	0.042	0.02
SEPT. 21	199	8.23	6.1	0.8	0.85	0.011	0.001	0.4	0.034	0.025
OCT. 5	202	8.28	6.4	1.2	0.9	0.013	0.0005	0.37	0.024	0.02
MEAN	206.44	8.28	5.73	1.79	1.01	0.012	0.001	0.3664	0.04	0.05

STATION 4 1987

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNP. TOTAL	PHOSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNP. R.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		ng/l	ng/l	Formazin U.	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l
MAR. 23	294	8.31	5.3	0.9	0.88	0.004	0.0005	0.32	0.02	0.185	0.0025
APR. 7	258	8.12	4.05	0.1	1.76	0.009	0.0005	0.2	0.002	0.105	0.0015
MAY 11											
MAY 25	248	8.2	4.6	2.7	2.3		0.0025		0.03	0.03	0.002
JUNE 9	218	8.14	5.3	3.4	1.16	0.015	0.0005	0.38	0.028	0.02	0.0045
JUNE 22	231	8.1	5.25	3.2	1.31	0.011	0.0005	0.35	0.042	0.04	0.008
JULY 6	218	8.25	5	4.1	1.25	0.008	0.0005	0.34	0.044	0.02	0.0025
JULY 20	226	8.18	5.65	2.9	1.49		0.0005	0.34	0.034	0.02	0.0025
AUG. 17	213	8.41	6.6	2.1	1.75	0.031	0.0015	0.3	0.038	0.075	0.003
SEPT. 8	204	8.19	6.3	1.8	1.12	0.016	0.0005	0.44	0.044	0.025	0.0025
SEPT. 21	207	8.16	6	1.4	1.2	0.031	0.0015	0.4	0.034	0.03	0.0035
OCT. 5	209	8.24	6.25	1	0.8		0.0135		0.018	0.035	0.0005
MEAN	232.36	8.21	5.48	2.15	1.4	0.016	0.002	0.341	0.03	0.051	0.0037

Appendix E: Continued

STATION 11 1983

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNF. TOTAL	PHOSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNF. N.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		ng/l	ng/l	Formazin U.	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l
MARCH 23	308	8.28	6.85	1.3	1.13	0.008	0.0005	0.28	0.246	0.23	0.0035
APRIL 7	269	8.14	4.85	4.2	1.46	0.012	0.0005	0.19	0.304	0.14	0.0025
MAY 11	256	8.24	4.8	3.6	2.6	0.013	0.001	0.34	0.234	0.22	0.0025
MAY 25	250	8.15	5	4.7	3.2	0.016	0.002	0.42	0.234	0.24	0.0025
JUNE 9	246	8.12	5.15	3.8	2.2	0.021	0.0005	0.39	0.23	0.225	0.0045
JUNE 22	238	8.05	5.6	7.5	2.2	0.16	0.001	0.43	0.248	0.255	0.006
JULY 6	233	8.21	5.2	6.2	2.3	0.012	0.0005	0.33	0.238	0.23	0.003
JULY 20	230	8.14	5.8	6.4	2.6	0.015	0.0005	0.37	0.246	0.235	0.003
AUG. 17	220	8.36	6.45	22.1	3.6	0.059	0.0015	0.54	0.238	0.29	0.0035
SEPT. 8	210	8.14	5.6	5.3	1.78	0.022	0.001	0.39	0.224	0.24	0.0025
SEPT. 22	223	8.1	5.9	2.6	1.85	0.01	0.0015	0.39	0.228	0.235	0.004
OCT. 5	225	8.18	6.25	1.6	1.15	0.012	0.0005	0.36	0.212	0.23	0.0015
MEAN	240.67	8.18	5.49	5.78	2.17	0.03	0.0009	0.3692	0.232	0.264	0.0034

STATION 11 1987

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNF. TOTAL	PHOSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNF. N.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		ng/l	ng/l	Formazin U.	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l
MARCH 23	325	8.27	7.5	1.3	0.78	0.009	0.001	0.3	0.22	0.345	0.0035
APRIL 7	314	8.21	7.8	1.8	0.96	0.016	0.0045	0.22	0.308	0.34	0.003
MAY 11	295	8.34	5.7	2.9	2.5	0.014	0.0005	0.36	0.266	0.22	0.0015
MAY 25	266	8.21	5.55	1.9	1.14	0.01	0.003	0.33	0.248	0.235	0.002
JUNE 9	250	8.21	5.55	2.1	1.06	0.011	0.001	0.37	0.24	0.22	0.004
JUNE 22	245	8.15	7.1	2.6	0.18	0.012	0.0015	0.36	0.242	0.24	0.003
JULY 6	235	8.37	5.25	13.4	1.36	0.006	0.0005	0.31	0.232	0.22	0.0015
JULY 20	231	8.41	6	1.1	0.65	0.01	0.003	0.33	0.234	0.22	0.002
AUG. 17	202	8.44	6.55	4.5	1.39	0.04	0.0025	0.38	0.242	0.275	0.0045
SEPT. 8	211	8.23	6.15	0.7	1.09	0.021	0.0015	0.4	0.232	0.215	0.002
SEPT. 22	221	8.16	6.2	0.9	0.9	0.011	0.0025	0.39	0.252	0.23	0.004
OCT. 5	220	8.27	6.6	0.1	0.54	0.012	0.005	0.38	0.236	0.23	0.002
MEAN	251.25	8.27	6.33	2.61	1.07	0.014	0.0022	0.3442	0.238	0.283	0.0029

STATION 12 1987

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNF. TOTAL	PHOSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNF. N.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		ng/l	ng/l	Formazin U.	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l
MARCH 23	320	8.32	6.8	1.1	1.88	0.007	0.0005	0.28	0.21	0.3	0.0035
APRIL 7	284	8.24	4.65	1.8	0.51	0.007	0.002	0.2	0.212	0.19	0.0045
MAY 11	273	8.38	4.9	3.6	2.3	0.012	0.0005	0.31	0.216	0.22	0.003
MAY 25	259	8.16	5.15	3.1	1.76	0.012	0.0035	0.3	0.22	0.26	0.0025
JUNE 9	245	8.21	5.3	3	1.35	0.021	0.001	0.42	0.22	0.28	0.004
JUNE 22	243	8.08	5.7	2.3	0.75	0.016	0.002	0.39	0.228	0.265	0.0035
JULY 6	240	8.27	5.3	9.3	2.4	0.012	0.0005	0.33	0.222	0.235	0.003
JULY 20	238	8.18	6.15	2.8	1.09	0.009	0.003	0.27	0.22	0.23	0.003
AUG. 17	225	8.37	6.4	3	1.77	0.038	0.0055	0.34	0.21	0.26	0.003
SEPT. 8	215	8.16	6	2	1.12	0.03	0.002	0.36	0.222	0.255	0.003
SEPT. 22	229	8.05	6.05	20.3	0.75	0.012	0.004	0.42	0.216	0.26	0.004
OCT. 5	219	8.17	6.3	1.1	1.85	0.011	0.009	0.43	0.234	0.26	0.002
MEAN	248.42	8.22	5.73	4.45	1.39	0.0156	0.0028	0.3375	0.22	0.285	0.0033

Appendix E: Continued

STATION 33 1987

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNF. TOTAL	PROSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNF. R.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		mg/l	mg/l	Formazin U.	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
MAR. 24	360	8.26	8.4	3.2	1.59	0.015	0.003	0.4	0.014	0.175	0.004
APRIL 7	348	8.29	8.65	3.4	1.54	0.015	0.0025	0.32	0.012	0.12	0.004
MAY 12	306	8.43	6.25	7.2	3.9	0.014	0.0055	0.36	0.048	0.02	0.009
MAY 25	284	8.27	6.2	5.8	3.6	0.017	0.011	0.37	0.054	0.03	0.003
JUNE 10	264	8.3	6.5	4.6	4.2	0.023	0.0045	0.47	0.052	0.045	0.01
JUNE 23	252	8.25	6	4.7	2.9		0.0045		0.054	0.04	0.0035
JULY 7	242	8.31	5.8	4.9	1.87	0.017	0.0045	0.4	0.048	0.025	0.003
JULY 21	239	8.46	9.7	3.9	1.88	0.018	0.003	0.37	0.04	0.02	0.004
AUG. 18	228	8.38	6.7	4.7	3.4	0.044	0.0065	0.46	0.05	0.04	0.0035
SEPT. 8	225	8.18	5.9	2.9	1.84	0.019	0.001	0.46	0.036	0.04	0.0025
SEPT. 22	225	8.21	6.25	2.8	2.2	0.011	0.002	0.37	0.026	0.02	0.004
OCT. 5	225	8.4	6.7	1.2	1.25	-0.007	0.001	0.34	0.012	0.02	0.001
MEAN	266.02	8.31	6.92	4.12	2.51	0.0184	0.0061	0.3927	0.038	0.05	0.0045

STATION 34 1987

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNF. TOTAL	PROSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNF. R.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		mg/l	mg/l	Formazin U.	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
MARCH 23	417	8.28	10.1	5.3	2.2	0.054	0.045	0.69	0.088	1.01	0.0415
APRIL 7	423	8.38	11.3	3.4	1.22	0.069	0.0475	0.42	0.054	0.71	0.045
MAY 12	492	8.47	11.85	4.1	2.8	0.102	0.0745	1.15	0.196	0.465	0.0725
MAY 26	499	8.49	8.7	3.7	2.1	0.67		0.8	0.08	0.1	0.934
JUNE 10	475	8.56	8.75	3.4	13.8	0.054	0.023	0.83	0.042	0.03	0.0135
JUNE 23	444	8.74	9	4.7	2.4	0.046	0.0655	1.29	0.108	0.05	0.019
JULY 20	464	8.29	6.1	11.2	2.6	0.082	0.041	0.88	0.04	0.02	0.0105
SEPT. 22	612	8.31	13.65	18	0.65	0.07	0.0585	0.71	0.034	0.025	0.005
OCT. 5	623	8.34	14	1.5	0.45	0.043	0.03	0.77	0.034	0.03	0.0015
MEAN	494.33	8.43	10.29	6.14	3.14	0.1371	0.050625	0.8589	0.074	0.271	0.0272

STATION 35 1987

DATE	CONDUCTIVITY	pH	CHLORIDE	RESIDUE PARTICULATE	TURBIDITY	PHOSPHORUS UNF. TOTAL	PROSPHATES FRAC. REACT.	NITROGEN TOT. KJELD UNF. R.	AMMONIUM TOTAL FRAC. REACT.	NITRATES TOT. FRAC. REACT.	NITRITE FRAC. REACT.
	umho/cm @ 25C		mg/l	mg/l	Formazin U.	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
MARCH 23	354	8.24	8.6	2.8	1.77	0.013	0.0045	0.34	0.018	0.14	0.0035
APRIL 7	422	8.31	27.5	3.7	1.76	0.081	0.0035	0.45	0.05	1.38	0.018
MAY 12	325	8.26	7.15	3.2	4.7	0.019	0.0075	0.44	0.064	0.02	0.006
MAY 26	286	8.3	6.35	9.1	5.7	0.016	0.016	0.39	0.074	0.03	0.005
JUNE 10	277	8.23	6.2	4.2	2.9	0.023	0.0065	0.45	0.056	0.035	0.004
JUNE 23	256	8.05	6.1	6.2	3.2	0.03	0.009	0.88	0.082	0.035	0.006
JULY 7	246	8.16	5.75	12.6	4.7	0.023	0.0085	0.42	0.066	0.03	0.0125
JULY 21	243	8.12	6.5	7.9	2.9	0.043	0.0065	0.56	0.032	0.02	0.0035
AUG. 18	234	8.32	6.6	4.6	2.8	0.049	0.005	0.44	0.06	0.04	0.004
SEPT. 8	225	8.12	6.4	2.3	2.7	0.033	0.002	0.51	0.028	0.025	0.0025
SEPT. 22	227	8.15	7.1	9.2	16.1	0.025	0.005	0.39	0.034	0.04	0.0055
MEAN	281.27	8.21	8.57	6.35	4.48	0.0322	0.014	0.1882	0.024	0.15	0.0037

Appendix E: Continued

STATION 36 1987

DATE	CONDUCTIVITY	PH	CHLORIDE	RESIDUE	TURBIDITY	PHOSPHORUS	PHOSPHATES	NITROGEN TOT.	AMMONIUM TOTAL	NITRATES TOT.	NITRITE
				PARTICULATE		UNF. TOTAL	FRAC. REACT.	EJELD UNF. N.	FRAC. REACT.	FRAC. REACT.	FRAC. REACT.
	umho/cm @ 25C		mg/l	mg/l	Formazin U.	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
MARCH 23	707	8.28	56	3	2.4	0.139	0.135	0.48	0.048	1.67	0.028
APRIL 7	652	8.29	48.5	4.1	1.94	0.06	0.055	0.38	0.032	1.25	0.021
MAY 22	891	8.36	95		4.9	0.155		0.52	0.064	1.08	0.058
MAY 26	961	8.35	86	43.8	15.4	0.31	0.143	1.05	0.044	1.69	0.0765
JUNE 10	837	8.28	73.5	0.8	1.54	0.21	0.12	0.68	0.02	3.16	0.216
JUNE 23	959	8.19	110	5.4	2.7	0.27	0.131	0.51	0.058	2.83	0.023
JULY 7	1062	8.25	145	58	13.2	0.265	0.245	0.5	0.038	0.865	0.185
JULY 22	986	8.19	138	10.1	0.93	0.26	0.27	0.78	0.328	0.445	0.0525
MEAN	870.63	8.27	94	17.89	5.22	0.2086	0.157	0.6125	0.079	1.624	0.0825

Appendix F: Indian River - Correlation Analyses Between Bacterial and Chemical Parameters, 1987.

Parameter	vs	Parameter	r value	Level of Significance	Parameter	vs	Parameter	r value	Level of Significance
Bacteria	vs	High Pollution Potential	0.41	PC.001	Total Kjeld Nitrogen	vs	Bacteria	0.23	PC.05
"	vs	Suspended Solids	0.19	PC.05	"	vs	Suspended Solids	0.38	PC.001
"	"	Turbidity	0.55	PC.001	"	"	Turbidity	0.7	PC.01
"	"	Total Phosphorus	0.22	PC.01	"	"	Total Phosphorus	0.41	PC.001
"	"	Diss. React. Phosphorus	0.1	ns	"	"	Diss. React. Phosphorus	0.21	PC.05
"	"	Conductivity	-0.07	ns	"	"	Ammonium	0.27	PC.01
"	"	Nitrates	-0.006	ns	"	"	Nitrates	-0.09	ns
"	"				"	"	Conductivity	-0.13	ns
Suspended Solids	vs	Turbidity	0.46	PC.001	Ammonium	vs	Bacteria	0.03	ns
"	"	Total Phosphorus	0.29	PC.001	"	"	Suspended Solids	0.18	ns
"	"	Diss. React. Phosphorus	0.05	ns	"	"	Turbidity	0.2	PC.05
"	"	Conductivity	0.06	ns	"	"	Total Phosphorus	0.17	ns
"	"	Nitrates	-0.11	ns	"	"	Diss. React. Phosphorus	0.11	ns
Turbidity	vs	Total Phosphorus	0.2	PC.05	"	"	Conductivity	-0.018	ns
"	"	Diss. React. Phosphorus	0.08	ns	"	"	Nitrates	-0.05	ns
"	"	Conductivity	0.09	ns	"	"			
"	"	Nitrates	-0.12	ns	Chloride	vs	Bacteria	0.12	ns
Total Phosphorus	vs	Diss. React. Phosphorus	0.38	PC.001	"	vs	Suspended Solids	-0.01	ns
"	"	Conductivity	0.04	ns	"	"	Turbidity	0.01	ns
"	"	Nitrates	0.27	PC.01	"	"	Total Phosphorus	0.37	PC.001
"	"				"	"	Diss. React. Phosphorus	0.45	PC.001
Diss. React. Phosphorus	vs	Conductivity	0.42	PC.001	"	"	Total Kjeld Nitrogen	0.15	ns
"	"	Nitrates	0.77	PC.001	"	"	Ammonium	0.04	ns
"	"				"	"	Nitrates	0.46	PC.001
Conductivity	vs	Nitrates	0.55	PC.001	"	"	Conductivity	0.48	PC.001

ns - not significant

Appendix G:

Indian River Watershed Discharges and Stages for the 1987 Sampling and Bathing Seasons.

STATION DATE	4 DISCHARGE cfs	4 STAGE ft	7 DISCHARGE cfs	7 STAGE ft	11 DISCHARGE cfs	11 STAGE ft	12 DISCHARGE cfs	12 STAGE ft	20 DISCHARGE cfs	20 STAGE ft	21 DISCHARGE cfs	21 STAGE ft	22 DISCHARGE cfs	22 STAGE ft	25 DISCHARGE cfs	25 STAGE ft	30 DISCHARGE cfs	30 STAGE ft	
AUGUST 23		44.35									1.402	51.35	0.300	41.135					
AUGUST 24	1.3505	36.405									0.6700	40.35	0.2700	36.35					
APRIL 7											0.1200	31.35	0.0100	7.5	2.6595	106.635	2.107	45	
APRIL 21	1.8500	36.25	0.6797	35	0.3553	15.635	0.9710	16.35	1.5310	27.5	0.0277	24.375	0.0100	1.35	1.3400	120.35	1.200	34.5	
MAY 5																			
MAY 6	1.5003	35	1.36	40.635	0.2156	31.5	0.7702	21.405	1.6712	21.135	0.0004	21.405	0.0070	1.35			1.40	35	
MAY 12	1.1030	35	1.6792	44.35	0.2107	16.35	1.2930	26.35	1.0079	31.405	0.0157	21.405	0.0010	6.35			1.4035	35	
MAY 20																			
MAY 25	1.657	34.375	1.5503	40	0.2951	10.135	1.2103	21.35	1.4035	20.125	0.0040	18.75	0.0030	10.405			1.0100	35	
MAY 26	2.1276	21.125	1.5477	40.425	0.2105	10.75	1.1001	20	1.4805	21.25	0.403	22.5	0.0107	10	1.0270	121.35	1.002	35.5	
JUNE 2	1.5016	32.5	1.6169	40	0.2200	17.5	1.4254	20.635	1.5900	30	0.405	16.405	0.0136	9.375	1.5020	120	1.3005	35	
JUNE 10	1.1200	35.635	1.4006	39.375	0.1206	12.5	1.2654	22.5	1.0177	16.75	0.400	16.75	0	1.35			1.3006	33	
JUNE 15	1.6102	27.5	1.3507	36.25	0.124	8.75	1.0167	21.405	1.5304	31.35	0.0073	10.125	0.0001	1.35	1.4011	126.405	1.3406	30	
JUNE 21	1.1370	27.5	1.1757	37.5	0.1301	12.5	1.4370	21.25	1.2760	20	0.0007	12.75	0	0	1.300	126.35	1.0220	31	
JUNE 29	1.2103	27.5	1.5020	40	0.1914	12.5	0.9160	16.35	1.1107	10.75	0	12.5	0	0	1.1027	126.35	1.110	30	
JULY 7	1.4700	20.75	1.722	40.625	0.152	6.25	1.407	22.35	1.4017	20	0.0010	10.75	0.0006	5	1.5005	127.5	1.500	34.9	
JULY 14	1.1065	29.375	1.3996	37.5	0.1297	5	1.1636	21.405	1.5020	21.25	0.001	15	0	0	1.431	127.5	1.4054	33	
JULY 21	1.1704	27.5	1.1203	35	0.1195	7.5	0.9024	21.25	1.43	20	0	0	0	1.35	1.1007	126.25	1.1209	30	
JULY 28	1.3507	20.125	1.3912	30.75	0.104	4.5	1.1652	21.325	1.1715	20	0	0	0	0	1.1591	124.75	1.1707	31.5	
AUGUST 5	1.2170	30	1.356	36.25	0.1500	12.5	1.6303	21.325	1.409	10.5	0	0	0	0	1.2104	127.5	1.2006	33	
AUGUST 11	1.5164	20.75	1.2253	30.125	0.1129	10.75	1.1039	10.75	1.3500	22.35	0	0	0.0001	1.35	1.4000	124.75	1.249	33	
AUGUST 17	0.9055	27.5	0.9397	40.625	0.105	5.5	1.4011	21.425	1.4751	20	0	0	0	0	1.2154	127.5	1.1071	32	
AUGUST 24	1.2039	20.375	1.4603	30.75	0.0100	4.375	1.2227	21.125	1.2403	20	0	0	0	0	2.5	1.103	126.25	1.2027	33
AUGUST 25											0.0025	16.405	0.0114	5.625	1.5034	120.625	1.1995	35	
SEPT. 1	1.1406	21.125	1.3592	40	0.1501	12.5	1.4532	25	1.2403	20	0.403	16.25	0.012	10	1.4079	120.625	1.4124	34	
SEPT. 21	1.1311	37.5		46.25	0.139	13	1.1009	20											
OCT. 8	1.10222857	1.3702105		0.16215		1.15186		1.6075555		0.0003400		0.0376		1.4690500		1.4103520			

Appendix G: Continued

STATION	31	31	31	31	31	31	31
DATE	WATERAGE	STAGE	WATERAGE	STAGE	WATERAGE	STAGE	WATERAGE
	m/sec.	cm	m/sec.	cm	m/sec.	cm	m/sec.
MARCH 23					0.46	70	0.0031
MARCH 24							
APRIL 1					0.5035	66.075	0.0205
APRIL 2					0.4910	55.125	0.0085
APRIL 21	0.0031	36.35	1.0007	35	0.0753	36.35	0.0006
MAY 5							
MAY 6	0.0077	20					
MAY 11							
MAY 12	0.0235	11.405	1.2039	35	0.41	20.35	0.0002
MAY 19							
MAY 20	0.0126	11.25	1.7910	11.25	0.0004	22.5	0.0029
MAY 25							
MAY 26	0.0670	13.35	1.0332	12.5	0.0031	35	0.0006
JUNE 1							
JUNE 2	0.0535	16.075	1.0212	12.5	0.0572	32.35	0.0001
JUNE 5							
JUNE 10	0.0070	7.5	1.6579	15	0.006	22.5	0.0000
JUNE 15					0.0039	21.5	
JUNE 16	0.0072	3.125	1.0035	16.35	0.0039	21.5	0.0006
JUNE 22							
JUNE 23	0.0005	2.5	1.2011	11.25	0.0064	35	0
JUNE 29							
JUNE 30	0.0003	2.5	1.0213	11.25	0.0020	22.5	0
JULY 6							
JULY 7	0.0002	2.5	1.0235	11.25	0	15	0.0002
JULY 13							
JULY 14	0.0010	3.75	1.406	12.5	0.0105	20.35	0.0012
JULY 20							
JULY 21	0.0006	2.5	1.0070	10	0.0013	25.635	0
JULY 27							
JULY 28	0	0	1.0703	12.5	0	10	0
AUGUST 4							
AUGUST 5	0	0	1.3514	13.35	0	0	0
AUGUST 10							
AUGUST 11	0	0	1.4011	12.35	0	0	0
AUGUST 13							
AUGUST 14	0.0001	5.635	1.2701	12.5	0	0	0
AUGUST 24							
AUGUST 25	0	0	1.1762	10.635	0	0	0
AUGUST 31							
SEPT. 1	0	0	1.2666	12.5	0	0	0.0002
SEPT. 21	0	0	1.204	10.305	0.0022	0	0
OCT. 0	0	0	1.4032	10.125	0.0007	01.35	0
SEALS	0.0104006		1.3637		0.46435		0.0207026
JUNE 1 - JUNE 31	0.0045153		1.210007		0.0075710		0.000273

Appendix H: Large Landowner Questionnaire

Name(s) of owner: (last name first)

Mailing Address:

Name of Respondent: same as above()
or

City or Town:

Postal Code:

Years owned _____ or
rented _____

County

Township

Total ha(acres) owned:

Total ha(acres) rented:

Total ha(acres) worked:

Conc. Lot

Telephone
Area Code

- | | | | | | |
|---------------------------------|------------|------------------|--------------|------------------|---------|
| 1. TYPE OF FARMING: | Livestock | Cash Crop | Veg. Fruit | Orchard | Other |
| Acreage Used : | _____ | _____ | _____ | _____ | _____ |
| 2. LIVESTOCK: | Diary | Beef | Swine | Sheep | Poultry |
| Number: | _____ | _____ | _____ | _____ | _____ |
| 3. WATERED: | Barnyard | Surface | Pond | Creek | Random |
| | | | Spring | Controlled | |
| 4. CASH CROP: | Corn | Beans | Small Grains | Hay | |
| Ha/Acres: | _____ | _____ | _____ | _____ | |
| 5. WOODLOT: | Yes | No | Size | _____ | |
| 6. TYPE OF WOODLOT: | Dry | Flooded | Hardwood | Softwood | Mixed |
| 7. HOUSING: | Tie | Freestall | Feedlot | Loose | |
| 8. SILO: | Horizontal | Tower | Poured | Slab | Sealed |
| 9. WINTER FEED: | In Barn | Stored-Feed/Yard | | Fence Row Manger | |
| 10. PASTURE: | No | Yes | Rotation | Grazing | |
| 11. MANURE SYSTEM: | Solid | Semi-solid | Liquid | | |
| 12. MANURE STORAGE | Yard | Pad | Pad/Walls | Tank | |
| 12a. DISTANCE FROM WATERCOURSE: | < 100 ft. | 100 - 500 ft. | > 500 ft. | | |

Appendix H: Continued

13. MANURE SPREAD:	Daily	Spring	Fall	Summer	Winter
14. On:	Hayfields	Pasturefields	Row Crops	Small Grains	
15. MANURE INCORPORATED:	No	Yes	Knife	Plowdown	Cultivate
16. MILKING SYSTEM:	Buckets	Station	Pipeline		
17. MILKHOUSE WASTE:	Septic	Lagoon	Surface		
18. WATER SOURCE:	Well	Dug	Bored	Drilled	Spring
19. DEPTH:	< 25'	26-50'	51-75'	76-100'	> 100'
20. PUMP:	Shallow	Deep	Piston	Jet	Submersible
21. WELL WATER CONTAMINANTS: Level:	Sulphur or Gas		Bacterial	Chemical	
22. WELL WATER USES:	Domestic	Livestock	Irrigation	Other _____	
23. QUALITY CHECK:	No	Yes	Since 1980	Since 1975	Before 1975
24. WATER TREATMENT:	No	Yes	Softener	Filter/Softener	
25. IRRIGATION:	No	Yes	Vegetables	Fruit or Tobacco	Other _____
26. AREA:	<2 ha.	3.5 ha.	6-10 ha.	10-15 ha.	> 16 ha.
27. TILE DRAINAGE	Systematic			Random	
28. AREA:	_____ (ha)		_____ (ha)		
29. OUTLETS TO:	Municipal Drain	Natural Watercourse	Ditch	Other Tile	

Appendix H: Continued

30. CROP CHANGE(ha): Since drainage	Hay Spring Grain	Corn Corn	Grass Hay Spring Grain	Alfalfa Soybeans	Other _____
31. FUTURE TILE Installation:	No	Yes			
32. PAST FLOODING:	No	Yes	Level Above Normal		_____
33. ICE PROBLEMS:	No	Yes	Problem		_____
34. RIVER WATER USES: Method:	Livestock Direct	Irrigation Pumped	Domestic	Other	_____
35. WATERCOURSE DRIES UP:	No	Yes	Dates		_____
36. EROSION PROBLEMS:	No	Yes	Gully	Sheet	Rill
37. AREA:	< 5 ha.	6-10 ha	11-25 ha.	> 26 ha.	
38. CAUSE:	Water	Wind	Soil	Slope	Crop
39. CONSERVATION TILLAGE:	No	Yes	Soil Saver	No Till	
40. CONSERVATION STRUCTURES:	No	Yes	Waterway	Drop Inlet	Riprap
41. FERTILIZER:	Spring only		Side Dress	Fall Application	
42. FERTILIZER RATES:	Actual Nkg/ha < 100 Pkg/ha < 60	101-125 61-100	126-150 101-150	151-175 151-200	175-200 > 200 > 200
43. SPRAY-ATRAZINE: Actual Rate:	No kg/ha	Yes < 2	3-4	5-6	> 6
44. SPRAY METHOD:	Field Sprayer		Low Volume-High Volume-Air		
45. TILLAGE TRACTORS:	# _____	Size < 50 hp	50 hp	50-90 hp	> 90 hp
46. HOUSE SEPTIC SYSTEM INSTALLED:	< 5 yrs	6-10	11-15	15-20	> 20
47. SEPTIC TANK PUMPED:	Once a year	Every 2	Every 5	Every 10	Never

APPENDIX I: CRITERIA FOR RANKING POLLUTION POTENTIAL OF LARGE

PROPERTY OWNERS (> 10 ACRES)

These criteria were developed using those from the Upper Thames River Livestock Manure & Waste Management Program 1985-1986 (D. Hayman, C. Merkley). A few minor revisions were made to include data from our own landowner questionnaires.

HIGH POTENTIAL:

- Livestock access.
- Inadequate manure storage and/or feedlot in close proximity to watercourse.
- Dairy operations with inadequate milkhouse waste management.
- Manure spread on fields and not incorporated into soil.
- Fields tile drained to natural watercourse or to drain emptying into natural watercourse.

MEDIUM POTENTIAL:

- Inadequate manure storage or feedlot which may run-off to open water under extreme conditions, however no visible evidence. Long gentle slope to watercourse with a good buffer.
- Contained storage which may be a problem in an overflow situation.
- Livestock access in very low numbers, no other problems (hobby farm size).

LOW POTENTIAL:

- No livestock access to watercourse
- Negligible slope to watercourse.
- Adequate manure storage and handling.
- No proximity of feedlot or manure storage to watercourse.

* Ranking of potential polluters was done in a subjective manner. A farm could be rated as having a high potential to pollute based on one large problem (i.e. 30 cattle with unrestricted access to a watercourse), or by meeting two or three of the criteria to a lesser degree, causing a cumulative effect.

APPENDIX J

LARGE PROPERTY OWNERS QUESTIONNAIRE RESULTS - 1986

The following data represent responses to questions and corresponding percentages of each response. "N" indicates the number of landowners each question applied to, out of the 133 landowners interviewed.

- Number of landowners with beef cattle:	77	58%	N = 133
Size of herd:			
1-19 :	16	12%	
20-49 :	39	29%	
50-74 :	12	9%	
75+ :	10	8%	
- Number of landowners with dairy cattle:	18	14%	N = 133
Size of herd:			
1-19 :	6	5%	
20-49 :	5	4%	
50-74 :	3	2%	
75+ :	4	3%	
- Number of landowners with both dairy and beef cattle:	5	4%	N = 133
- Amount of acreage owned by landowners:			N = 133
11-49 acres :	15	11%	
50-74 acres :	10	8%	
75-99 acres :	16	12%	
100-149 acres :	41	31%	
150-199 acres :	23	17%	
200+ acres :	28	21%	
- Landowners who are renting their land:	32	24%	N = 133
- Landowners with livestock:	96	72%	N = 133
- Landowners growing crops:	95	71%	N = 133
- Landowners with livestock and crops:	77	58%	N = 133
- Landowners growing vegetables, fruit or orchards:	4	3%	N = 133
- Landowners with poultry:	2	2%	N = 133
swine:	4	3%	
sheep:	0		

Appendix J: Continued

- Landowners who water their livestock randomly:			N = 96
in the river:	56	58%	
in the creek:	14	11%	
- Landowners growing corn:	25	26%	N = 95
grains:	44	46%	
hay:	80	84%	
- Type of manure storage system used by livestock operations:			
solid:	87	91%	N = 96
semi-solid:	14	15%	
liquid:	5	5%	
*some farms have more than one manure storage system			
- Type of containment for manure system:			N = 96
yard:	72	75%	
pad:	12	13%	
pad/walls:	1	1%	
tank or pit:	3	3%	
unknown:	7	7%	
- Distance of manure storage area from watercourse:			N = 96
<100 feet:	1	1%	
100-500 feet:	24	25%	
>500 feet:	71	74%	
- Manure spread:			N = 96
daily:	0		
spring:	28	29%	
summer:	19	20%	
fall:	22	23%	
winter:	0		
year round:	14	15%	
unknown:	13	14%	
- Manure spread on:			N = 96
hayfields:	62	65%	
pasturefields:	9	9%	
row crops:	3	3%	
small grains:	4	4%	
unknown:	18	19%	
- Type of milking system employed:			N = 18
buckets:	7	39%	
pipeline:	8	44%	
station:	1	6%	
unknown:	2	11%	

: Appendix J: Continued

- Milkhouse waste goes to:			N = 18
septic:	2	11%	
lagoon:	1	6%	
surface:	8	44%	
unknown:	7	39%	
- Type of well:			N = 133
dug:	77	58%	
bored:	0		
drilled:	35	26%	
spring:	2	2%	
none:	19	14%	
- Depth of well:			N = 114
1 - 25 feet:	9	8%	
25-50 feet:	31	27%	
51-75 feet:	12	11%	
76-100 feet:	0		
>100 feet:	1	1%	
unknown:	61	55%	
- Type of pump:			N = 114
shallow:	17	15%	
deep:	12	11%	
piston:	21	18%	
jet:	46	40%	
submersible:	8	7%	
unknown:	10	9%	
- Well water contaminants:			N = 114
sulphur:	5	4%	
gas:	0		
bacterial:	19	17%	
chemical:	0		
none:	90	79%	
- Well water uses:			N = 114
domestic:	108	95%	
livestock:	73	64%	
irrigation:	0		
other:	0		
- Well water was last tested :			N = 114
since 1980:	68	60%	
since 1975:	11	10%	
before 1975:	1	1%	
never:	35	31%	
- Those with water treatment systems:			N = 114
softener:	37	32%	
filter:	7	6%	
none:	89	78%	

Appendix J: Continued

- Landowners with tile drained fields:	systematic:	8	6%	N = 133
	random:	10	8%	
- Tile drain outlets to:	municipal drain:	2	11%	N = 18
	natural watercourse:	14	78%	
	ditch:	7	39%	
*some have more than one outlet				
- Landowners planning future tile installation:	yes:	10	7%	N = 133
	no:	122	92%	
	don't know:	1	1%	
- Landowners who have experienced ice problems:	yes:	1	1%	N = 133
	no:	131	98%	
	don't know:	1	1%	
- River water uses:	livestock:	57	43%	N = 133
	irrigation:	0		
	domestic:	3	2%	
	other:	0		
	none:	73	55%	
- Method of river water use:	direct :	57	97%	N = 59
	pumped:	0		
	no response:	2	3%	
- Landowners with creeks which dry up in summer:		44	33%	N = 133
- Landowners with erosion problems:		2	2%	N = 133
- Type of erosion problem:				
	gully:	0		N = 2
	sheet:	1	50%	
	rill:	0		
	don't know:	1	50%	
- Area affected by erosion problem:				
	<5 acres:	1	50%	N = 2
	6-10 acres:	1	50%	
	11-25 acres:	0		
	>25 acres:	0		

Appendix J: Continued

- Farmers implementing conservation tillage:				
soil saver:	3	2%	N = 133	
no till:	0			
- Method of fertilizer application:				
spring	60	63%	N = 95	
side dress:	2	2%		
year round:	1	1%		
never:	32	34%		
- Fertilizer application rate:				
<100 lb./acre:	50	53%	N = 95	
100-125 lb./acre:	6	6%		
126-150 lb./acre:	12	13%		
151-175 lb./acre:	0			
>175 lb./acre:	27	28%		
- Atrazine application:				
Yes:	25	26%	N = 95	
No:	70	74%		
- Atrazine application rate:				
<2 lb./acre:	1	4%	N = 25	
3-4 lb./acre:	3	12%		
5-7 lb./acre:	0			
>6 lb./acre:	21	84%		
- Method of application:				
field sprayer-low volume:	7	28%	N = 25	
field sprayer-high volume:	0			
air:	0			
no response:	18	72%		
- Homes with a septic system:				
Yes:	109	82%	N = 133	
No:	23	17%		
No response:	1	1%		
- Septic system pumped:				
yearly:	3	3%	N = 109	
every 2 years:	17	15%		
every 5 years:	27	25%		
every 10 years:	1	1%		
when necessary:	39	36%		
never:	22	20%		

Appendix K: Small Property Questionnaire

Landowner Identification Number:
Interviewer :

Date:

Name(s) of Owner:
Name of Respondent: Same as above ()
Or:

Mailing Address: _____ Postal Code: _____
 Township: _____ Lot: _____ Concession: _____ County: _____
 Telephone Number: _____ Area Code: _____

Building Description

Appearance:

Years Owned: _____ Or Rented: _____

Size of Lot:

Number of Bedrooms: Number of Occupants:

Type of Occupancy: Permanent Seasonal Weekends Other

Water Supply

Well Type: Dug Drilled Bored Other

Depth of Well: <25' 26-50' 51-75' 76-100' >100'

Water Quality

Date of Last Water Test:
Parameters:
Result:

Water Treatment: ☐ None ☐ Softener ☐ Filter ☐ Other

Where does waste water from treatment system drain to?

Well Water Uses: Domestic Livestock Irrigation Other

Sewage Disposal

Type of Disposal System:

Year of Installation:

Size of Tank: Length of Tile:

Type of Tank: Concrete Steel Fibreglass Plastic

Appendix K: Continued

How Often is the Tank Pumped?

Other Wastes

Do you have a sump pump?

What is drained by the sump pump?

Where does this discharge to?

Where does your laundry waste go?

Do you keep any animals on this property?

What soil type is your property?

Observations

Recommendations

APPENDIX L

SMALL PROPERTY OWNERS SURVEY RESULTS - 1987

The following data represent responses to questions and corresponding percentages of each response. "N" indicates the number of landowners each question applied to out of the 259 landowners interviewed.

CATEGORY	NUMBER	PERCENT	
Homes owned	249	96.14	(N=259)
Homes rented	3	1.16%	
No response	7	2.70%	
Bedrooms: 0	6	2.32%	(N=259)
1	10	3.86%	
2	61	23.55%	
3	148	57.14%	
4	16	6.18%	
5	3	1.16%	
>=6	12	4.63%	
no response	0	0	
not applicable	3	1.16%	
Occupants: 1	23	8.88%	(N=259)
2	109	42.08%	
3	39	15.06%	
4	43	16.60%	
5	20	7.72%	
6	9	3.47%	
>6	4	1.54%	
unknown	12	4.63%	
Occupancies type:			
permanent	110	42.47%	(N=259)
seasonal	81	31.27%	
weekends	52	20.08%	
other	5	1.93%	
no response	11	4.25%	
Type of well:			
dug	62	23.94%	(N=259)
bored	7	2.70%	
drilled	111	42.86%	
spring	3	1.16%	
none	65	25.1%	
no response	11	4.25%	

Appendix L: Continued

CATEGORY	NUMBER	PERCENT	
Depth of well:			
<25'	72	39.34%	(N=183)
26'-50'	63	34.43%	
51'-75'	19	10.38%	
76'-100'	10	5.46%	
>100'	2	1.09%	
unknown	17	9.29%	
Water last tested:			
within 1 year	94	36.29%	(N=259)
2-5 years ago	53	20.46%	
6-10 years ago	4	1.54%	
>10 years ago	11	4.25%	
never	31	11.97%	
not applicable	56	21.62%	
no response	10	3.86%	
Contaminants:			
bacterial	8	3.09%	(N=259)
sulphur	1	0.39%	
gas	0	0	
chemicals	0	0	
none	154	59.46%	
no response or			
not applicable	96	37.07%	
Treatments:			
softener	22	8.49%	(N=259)
filter	29	11.2%	
softener/filter	6	2.32%	
none	147	56.76%	
not applicable			
or no response	55	21.24%	
Treated water drains to			
septic	25	9.65%	(N=259)
dry well	3	1.16%	
overground	1	0.39%	
underground	0	0	
no response	33	12.74%	
not applicable	197	76.06%	
Well water uses			
*domestic	201	77.61%	(N=259)
*some of livestock	0	0	
these irrigation	0	0	
are other	1	0.39%	
lake-			
water not applicable	57	22.01%	

Appendix L: Continued

CATEGORY	NUMBER	PERCENT	
Sewage disposal type:			
outhouse with hole in ground	12	4.63%	(N=259)
outhouse with bucket or vault	2	0.77%	
septic system	218	84.17%	
humous toilet	1	0.39%	
holding tank	13	5.02%	
none	2	0.77%	
*other	4	1.54%	
no response	7	2.70%	
*pot pourri or electric toilet			
Years of installation:			
before 1960	10	3.89%	(N=257)
1960-1969	51	19.84%	
1970-1979	83	32.3%	
1980-1987	113	43.97%	
Size (gallons):			
less than 300	38	16.45%	(N=231)
300-499	9	3.9%	
500-799	38	16.45%	
800-1000	0	0	
greater than 100	32	13.85%	
unknown	114	49.35%	
Tile length:			
less than 75'	91	41.74%	(N=218)
75'-149'	0	0	
150'-249'	16	7.34%	
250'-299'	4	1.83%	
300' or more	61	27.98	
unknown	46	21.10%	
Type of tank:			
concrete	179	77.49%	(N=231)
steel	28	12.12%	
fiberglass	2	0.87%	
plastic	1	0.43%	
other	1	0.43%	
unknown	20	8.67%	

Appendix L: Continued

CATEGORY	NUMBER	PERCENT	

Tanked pumped:			
every 1-2 years	33	13.47%	(N=245)
every 3-5 years	45	18.37%	
when necessary	49	20.00%	
never	114	46.5%	
no response	4	1.63%	
Have a sump pump:			
yes	71	27.41%	(N=259)
no	181	69.88%	
no response	7	2.70%	
What does it drain:			
basement or			(N=71)
crawl space	43	60.56%	
laundry water	5	7.04%	
tap water	0	0	
well	2	2.82%	
*other	19	26.76%	
not in use	2	2.82%	
*other usually = sewage			
to septic or holding			
tank			
Where does it drain:			
septic	25	36.23%	(N=69)
dry well	4	5.8%	
overground	35	50.72%	
underground	1	1.45%	
holding tank	2	2.9%	
no response	2	2.9%	
Laundry waste:			
yes	143	55.21%	(N=259)
no	108	41.7%	
no response	8	3.09%	
Where does it drain to:			
septic system	119	83.22%	(N=143)
dry well	10	6.99%	
overground	7	4.9%	
underground	0	0	
holding tank	7	4.9%	
no response	0	0	

Appendix L: Continued

CATEGORY	NUMBER	PERCENT	

Animals kept here:			
yes	111	42.86%	(N=259)
no	141	54.44%	
no response	7	2.70%	
What kind:			
dog	81		
cat	24		
horse	3		
cattle	2		
poultry	7		
Soil type:			
rock	120	46.33%	(N=259)
sand	82	31.66%	
clay	16	6.18%	
gravel	9	3.47%	
loam	12	4.63%	
unknown	20	7.72%	

